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**Lee et al.**

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(54) **STRUCTURE OF TRANSMISSION AND  
RECEPTION UNIT IN WIRELESS  
CHARGING SYSTEM**

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**H02J 7/00** (2006.01)  
**H02J 7/02** (2006.01)  
**H01F 38/14** (2006.01)  
**H04B 5/00** (2006.01)  
**H01F 27/36** (2006.01)

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CPC ..... **H02J 7/0052** (2013.01); **H02J 7/0047** (2013.01); **H02J 7/025** (2013.01); **H01F 27/365** (2013.01); **H01F 38/14** (2013.01); **H02J 7/0004** (2013.01); **H04B 5/0037** (2013.01)

(58) **Field of Classification Search**

CPC ..... H02J 7/025; H02J 7/005; H02J 7/0047;  
H01F 27/365; H01F 38/14; H01B 5/0037;  
B60L 11/1829

USPC ..... 320/108  
See application file for complete search history.

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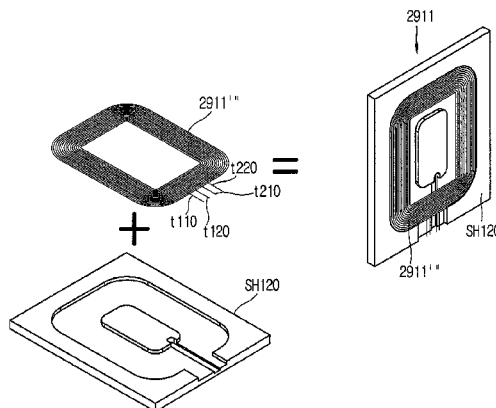
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(57) **ABSTRACT**

The present disclosure provides the structure of a transmission and reception unit in a wireless charging system. To this end, according to an embodiment, there is provided a wireless power receiver configured to receive a wireless power signal from a wireless power transmitter to receive wireless power, and the wireless power receiver may include a receiving coil unit comprising a primary coil and a secondary coil receiving the wireless power signal; and a charger configured to charge power which is a sum of wireless power received by the primary coil and the secondary coil, respectively, based on the wireless power signal.

**14 Claims, 24 Drawing Sheets**



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FIG. 1



FIG. 2A

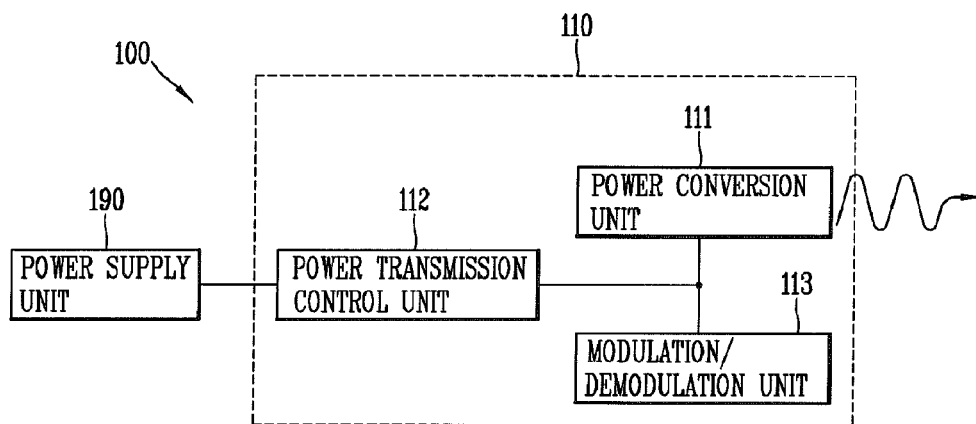


FIG. 2B

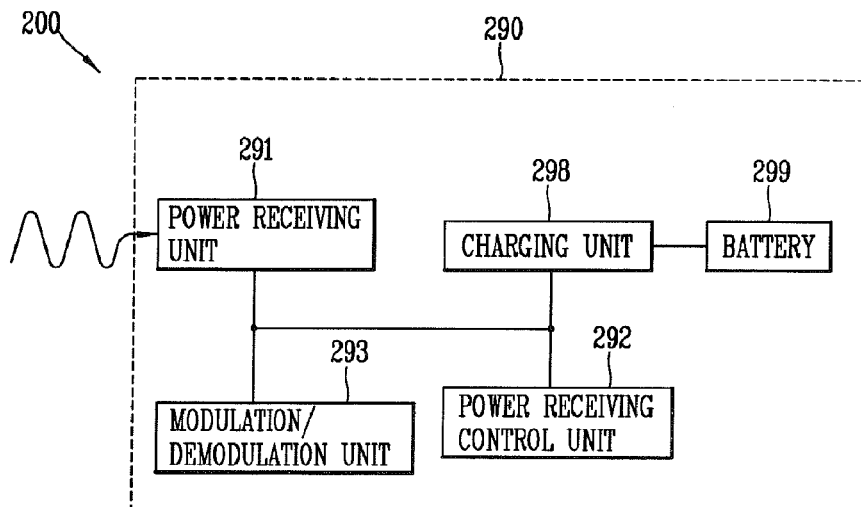


FIG. 3

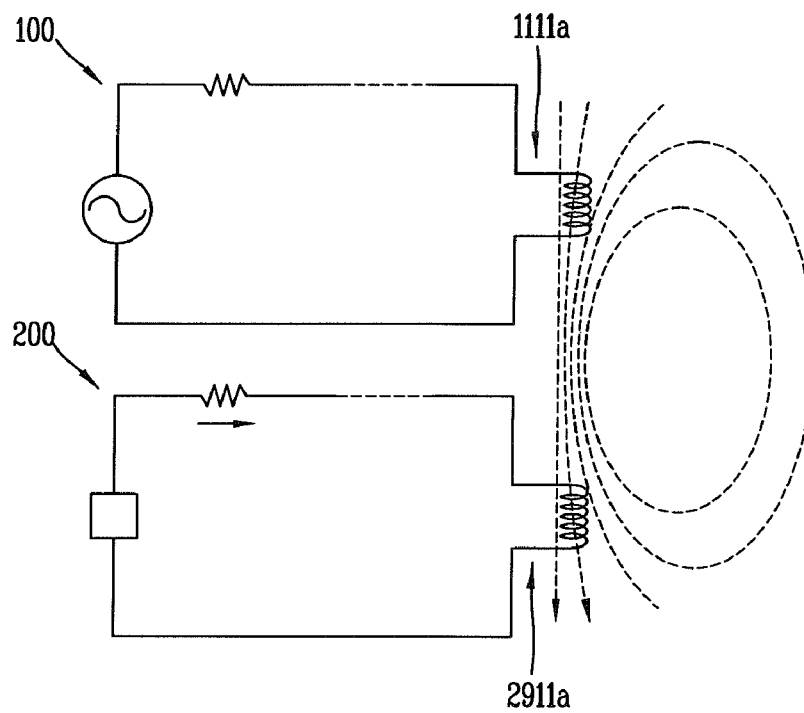


FIG. 4A

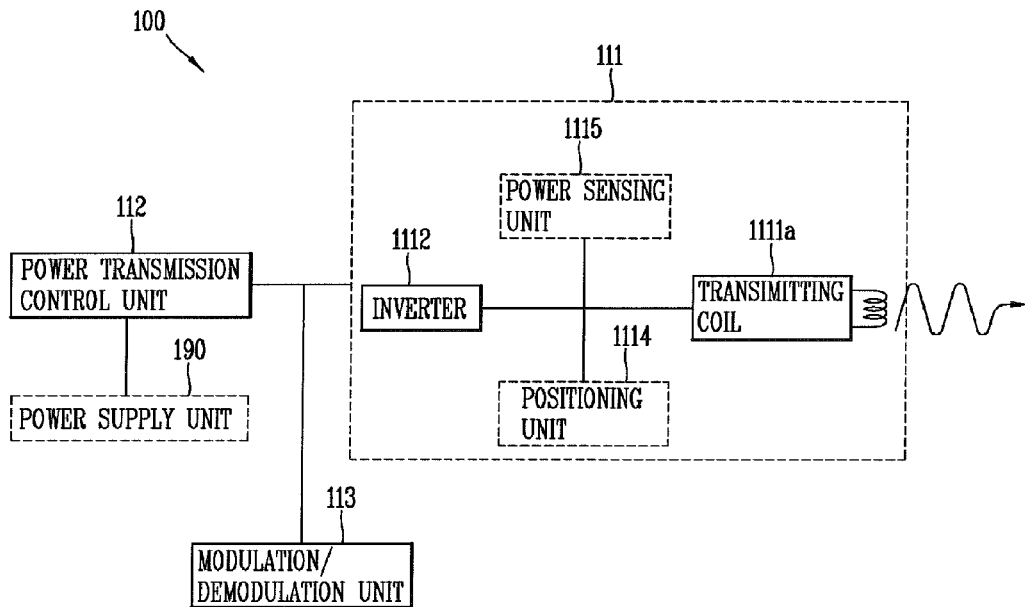


FIG. 4B

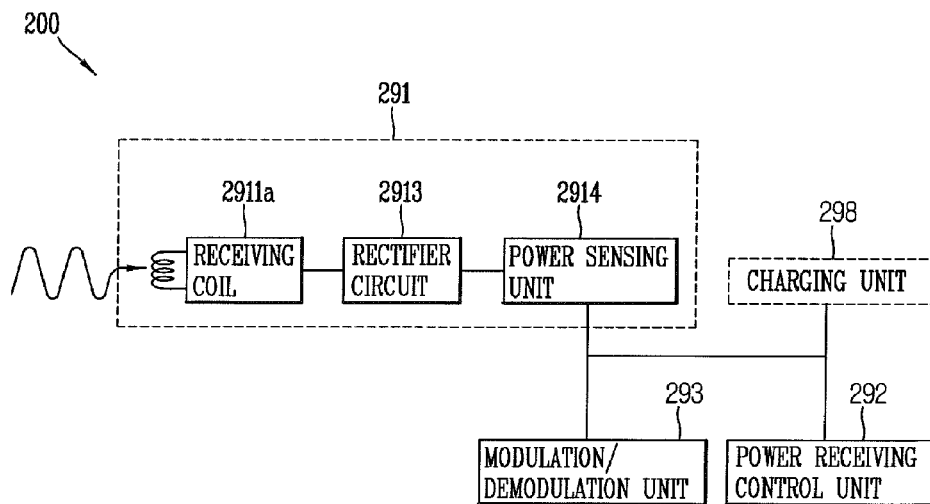


FIG. 5

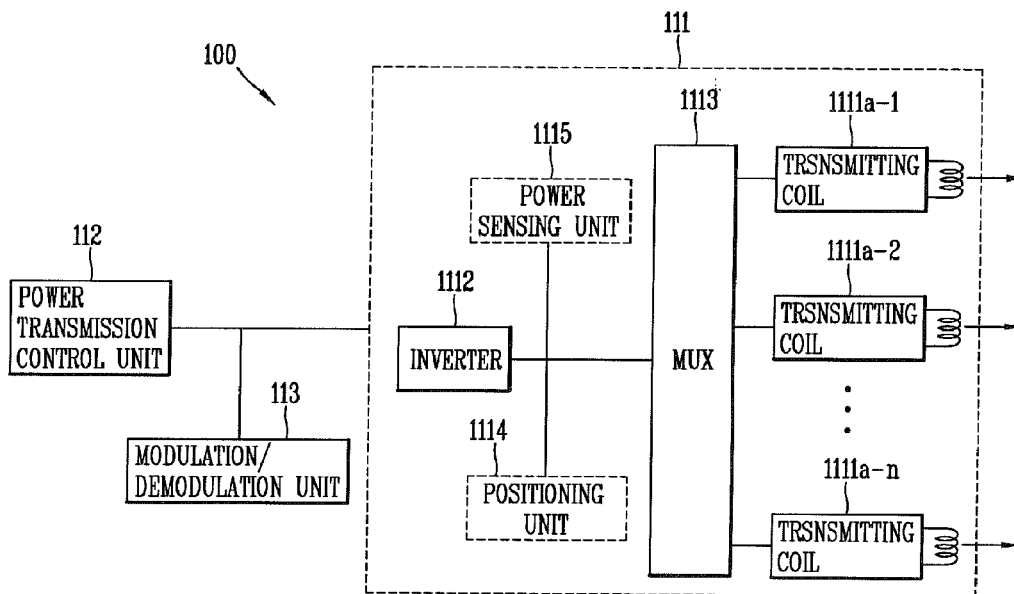


FIG. 6

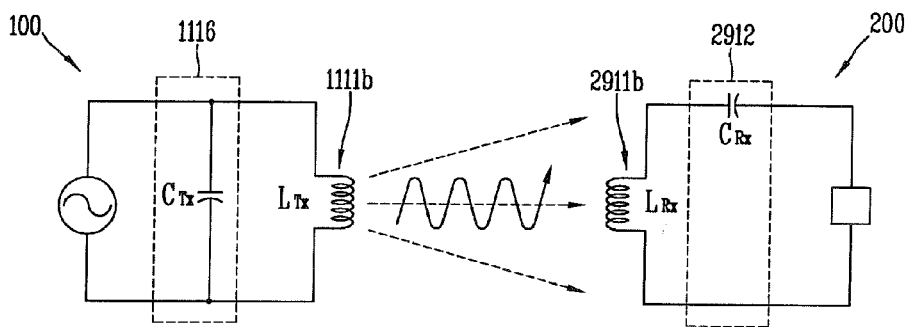


FIG. 7A

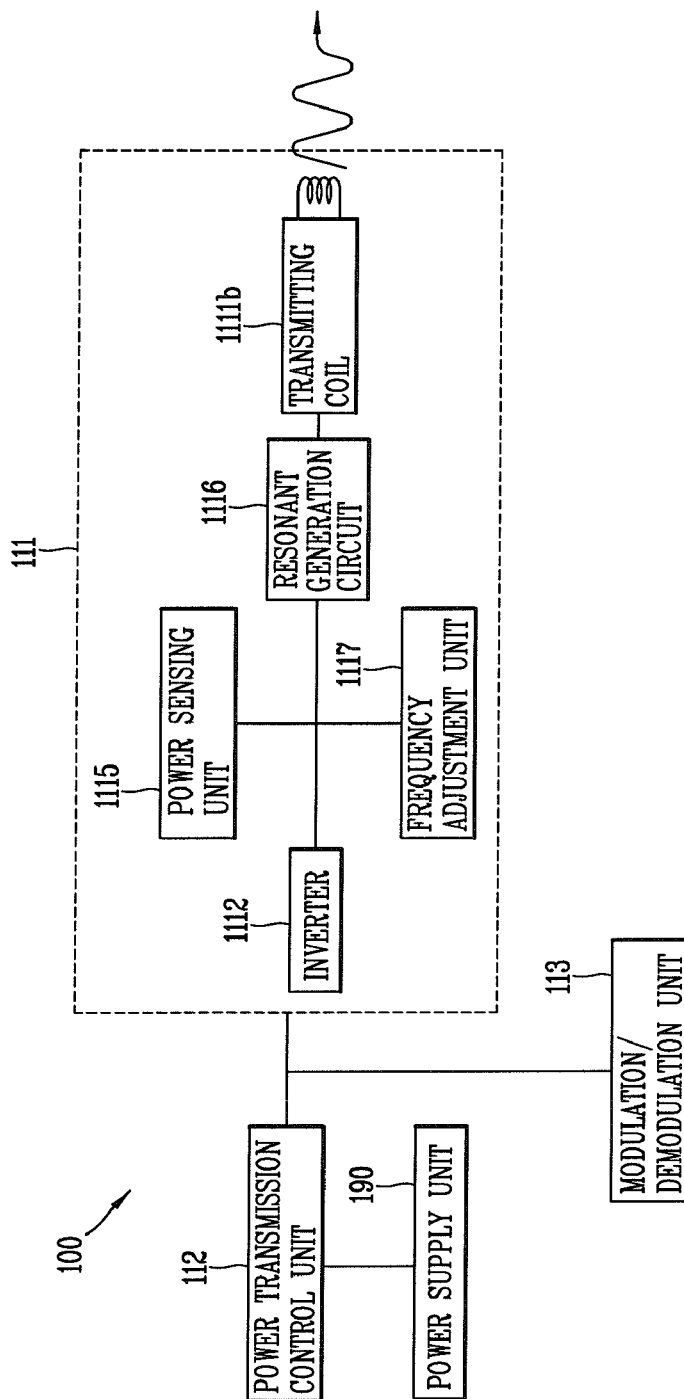


FIG. 7B

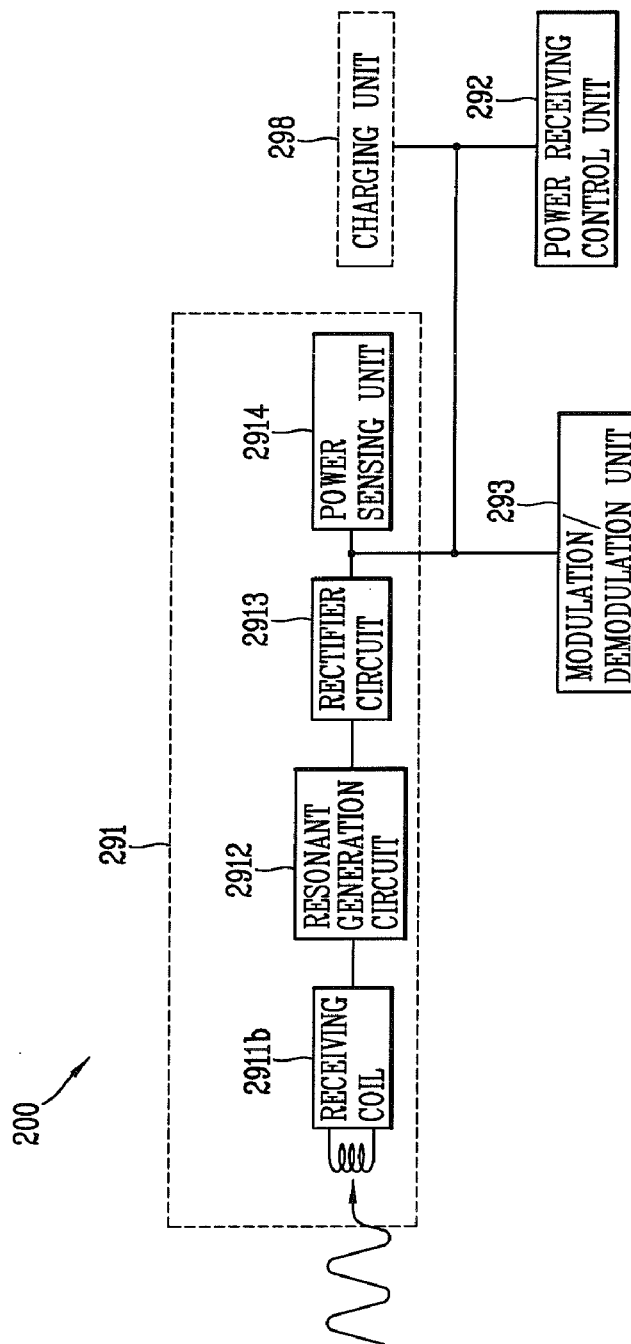


FIG. 8

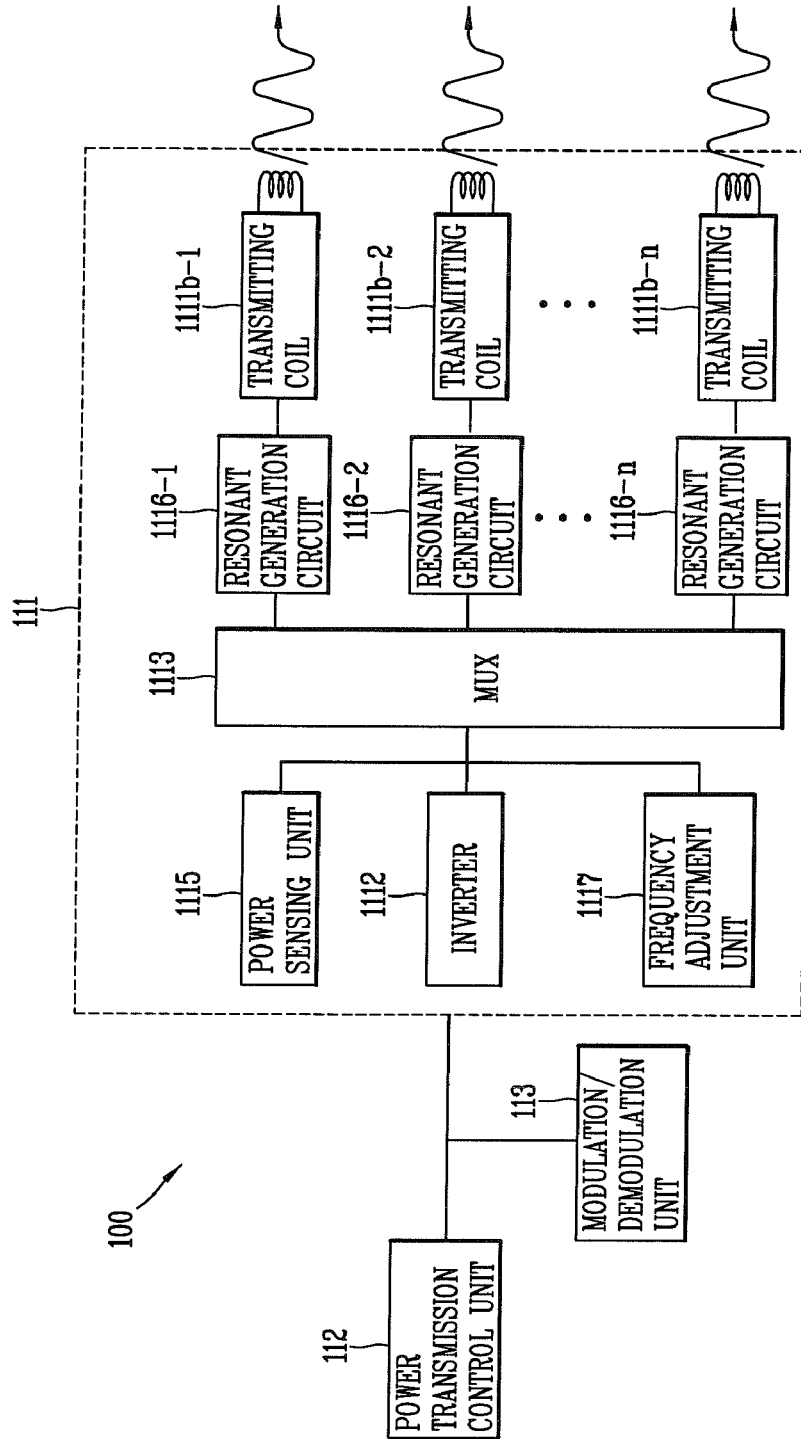


FIG. 9

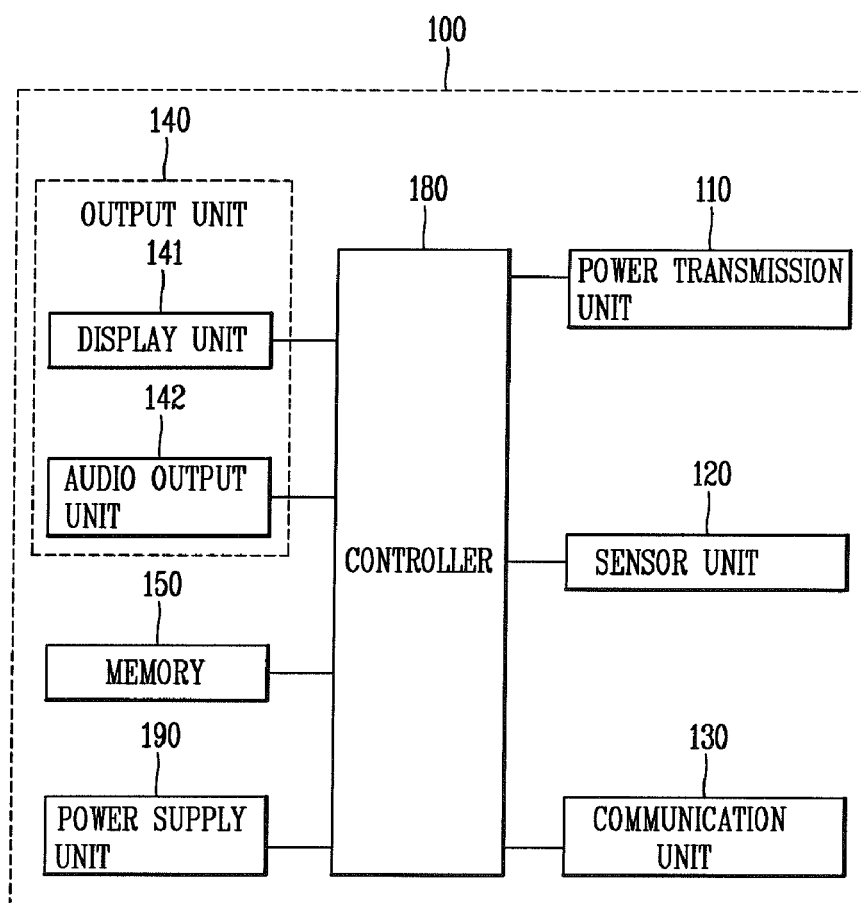


FIG. 10

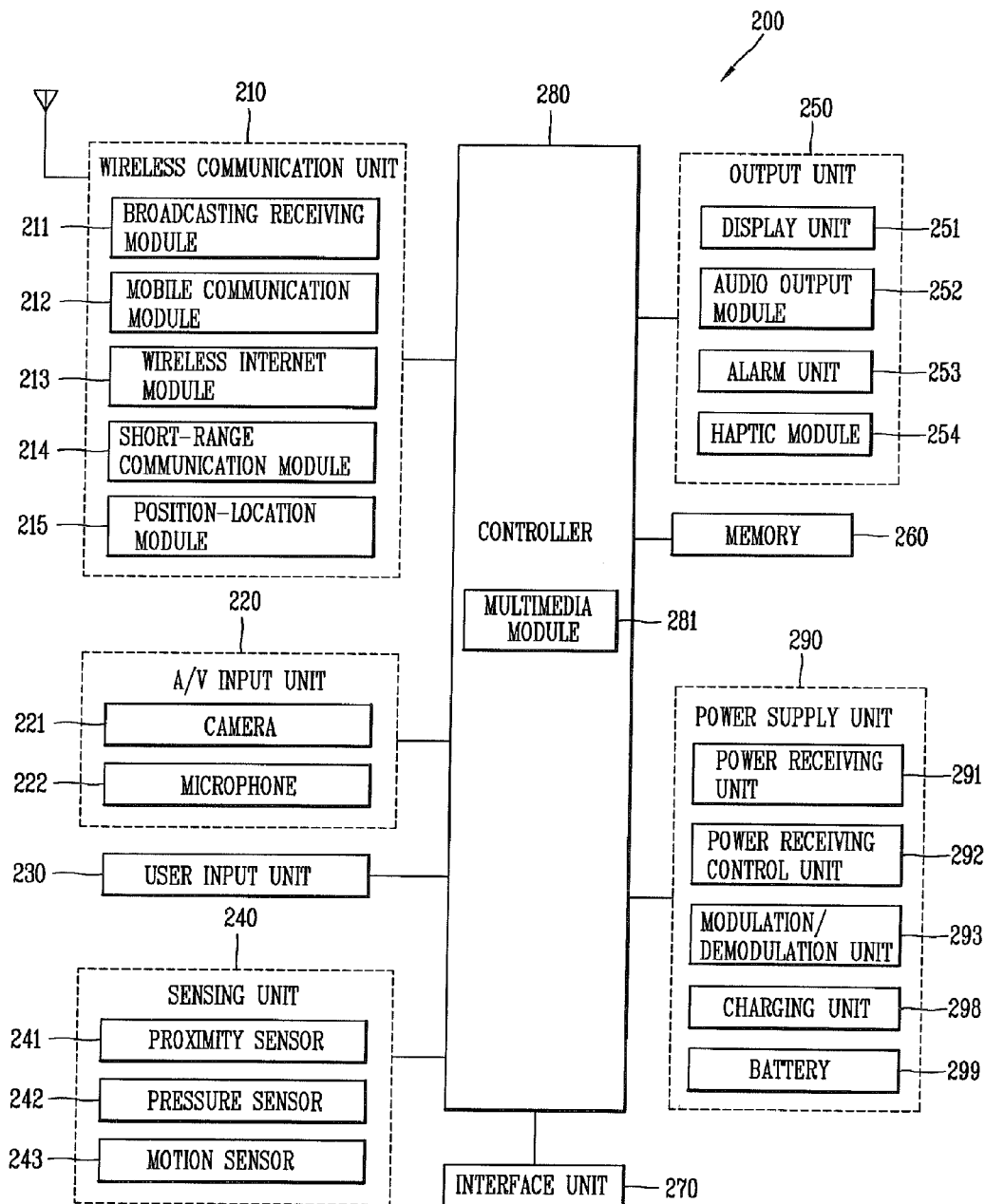


FIG. 11A

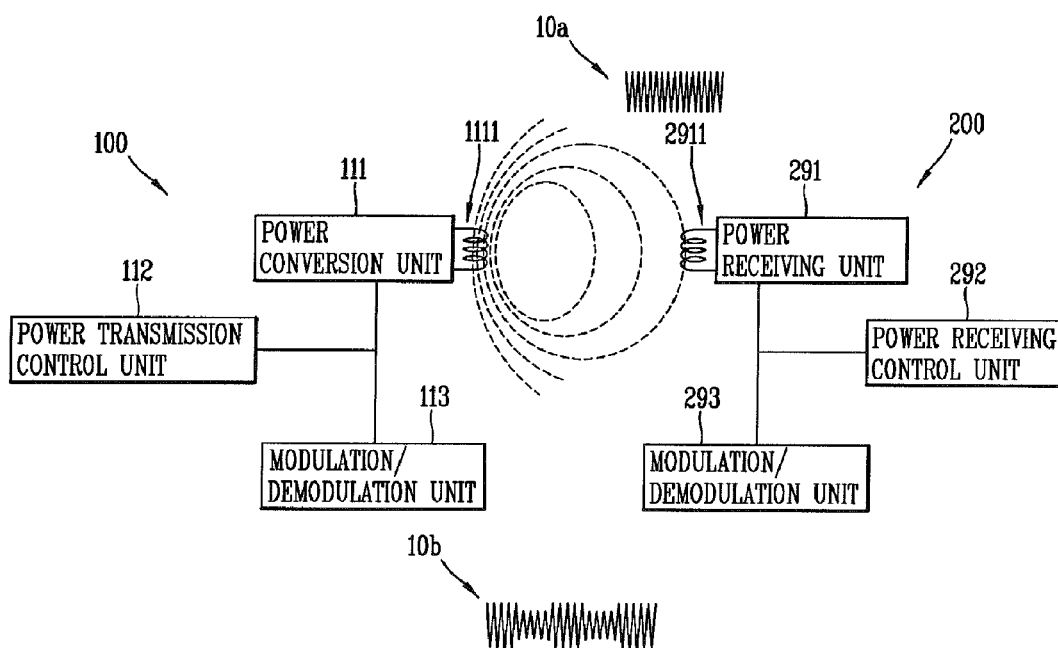


FIG. 11B

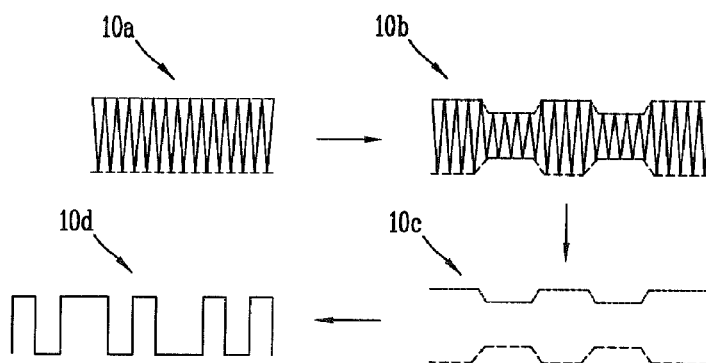


FIG. 12A

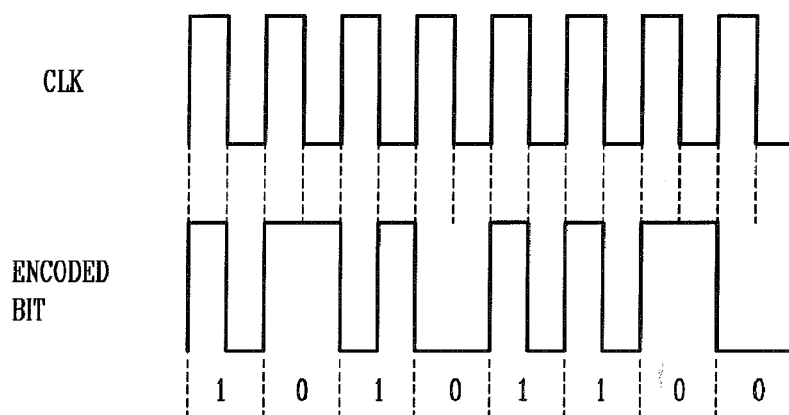


FIG. 12B

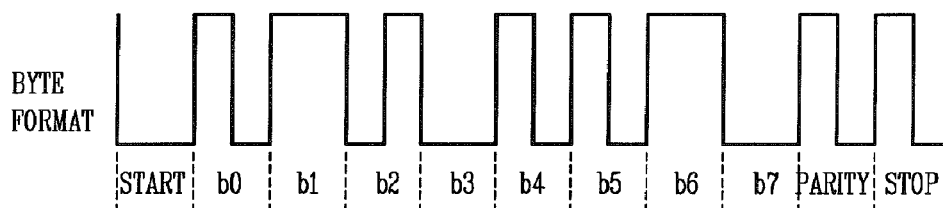


FIG. 13

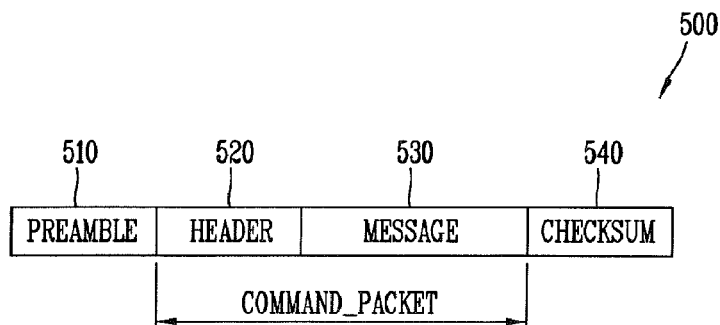


FIG. 14

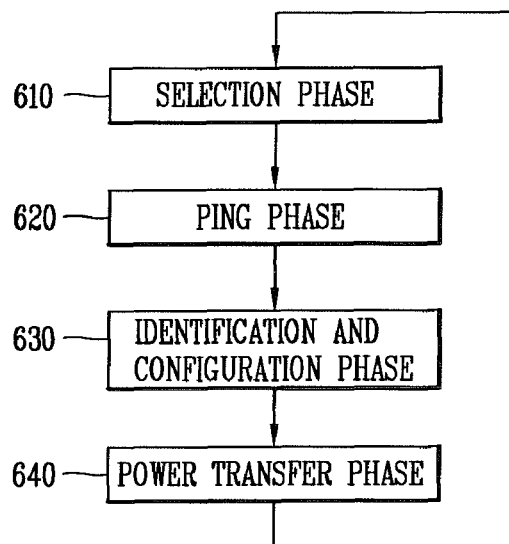


FIG. 15

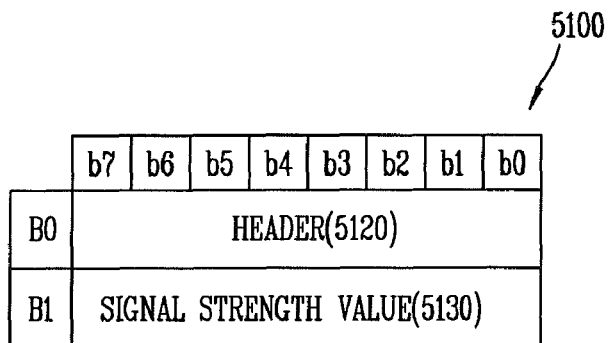


FIG. 16A

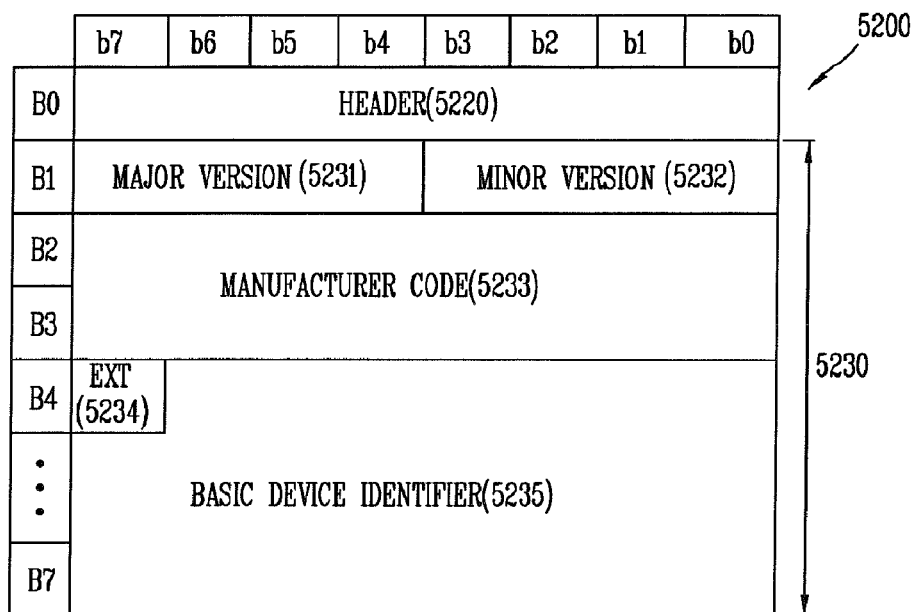


FIG. 16B

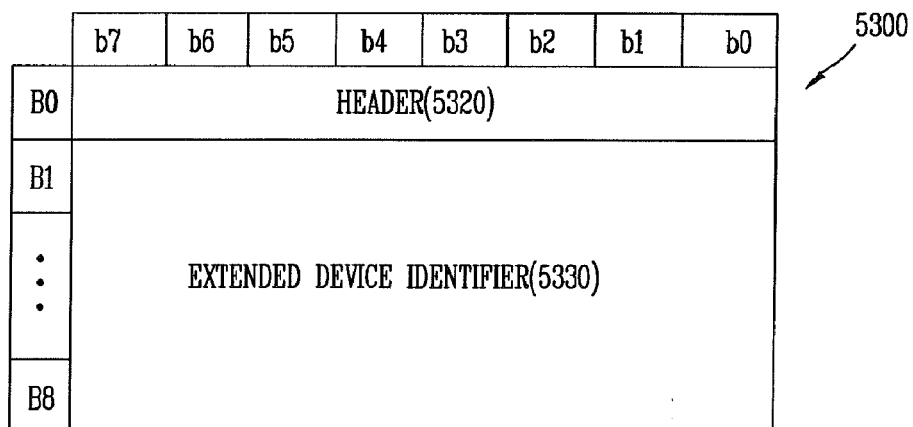


FIG. 17

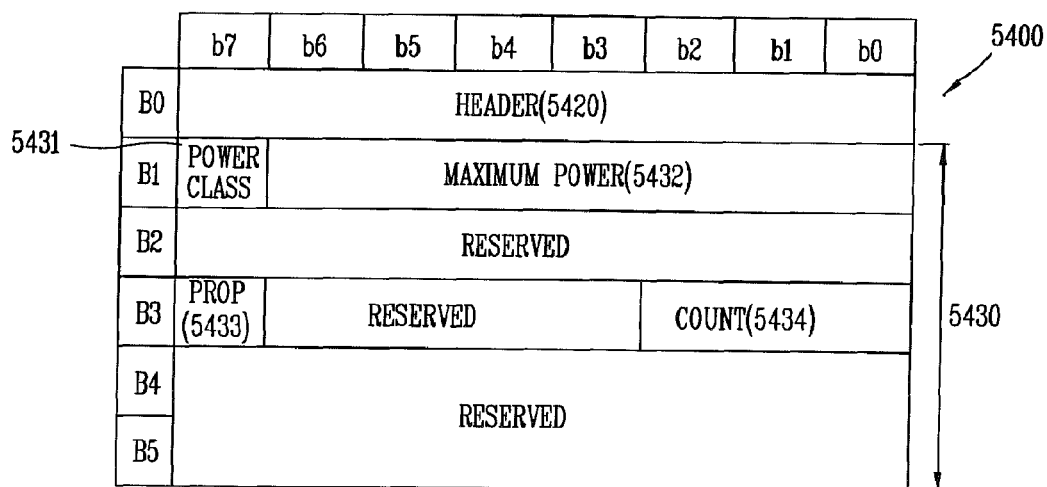


FIG. 18

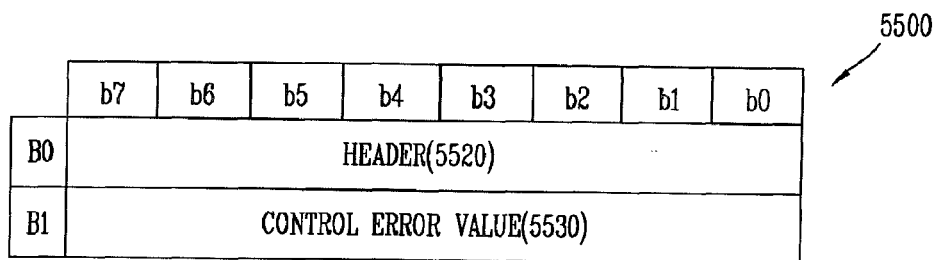


FIG. 19

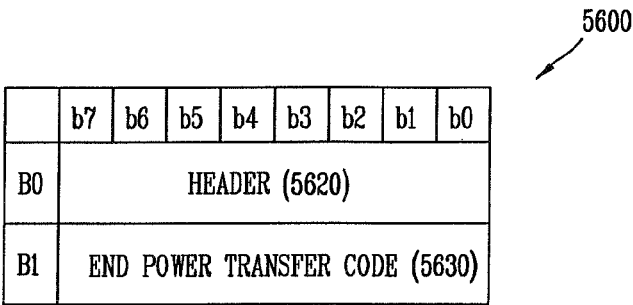


FIG. 20

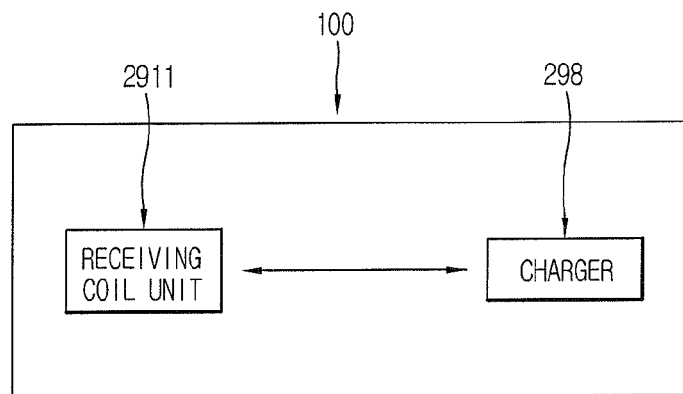


FIG. 21

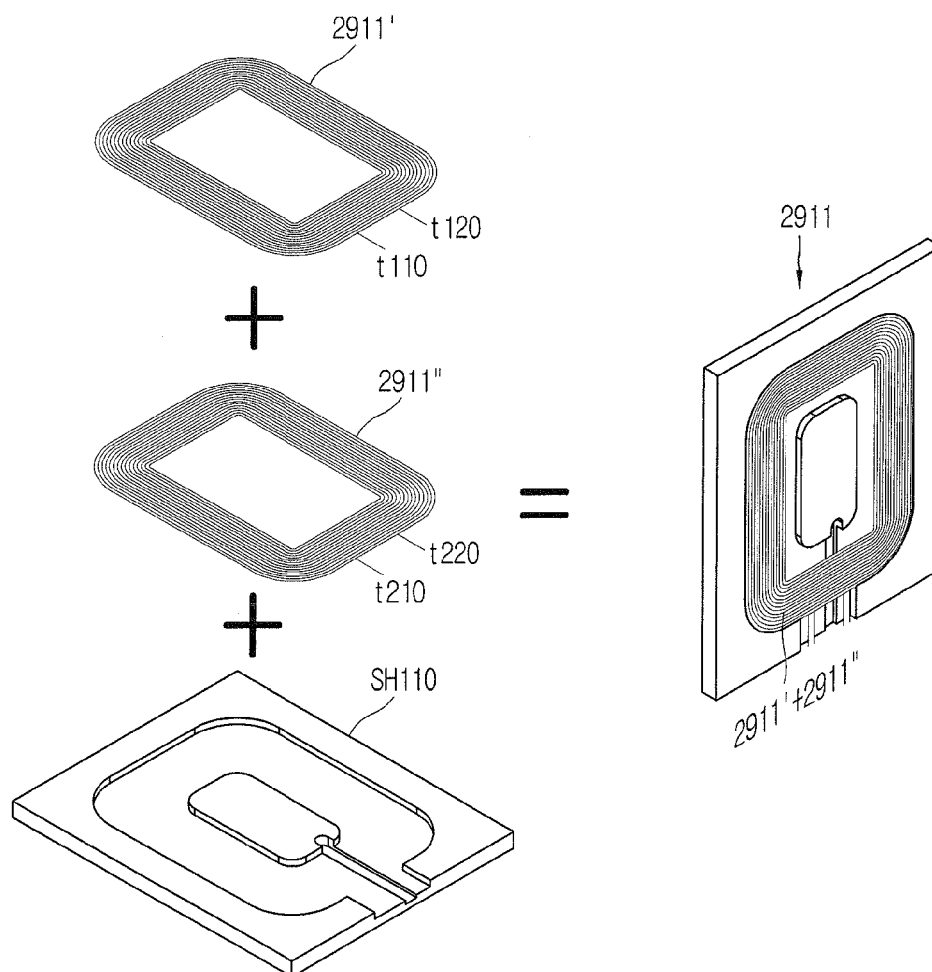


FIG. 22

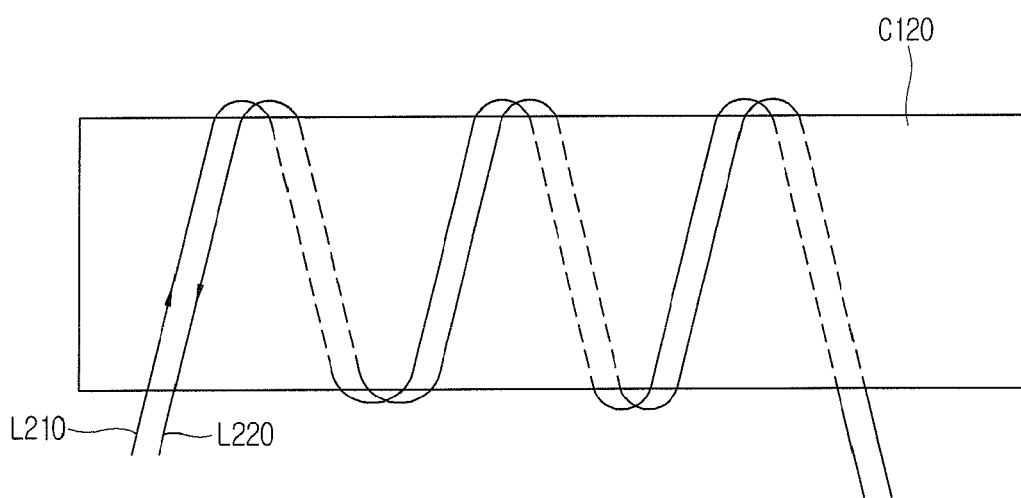
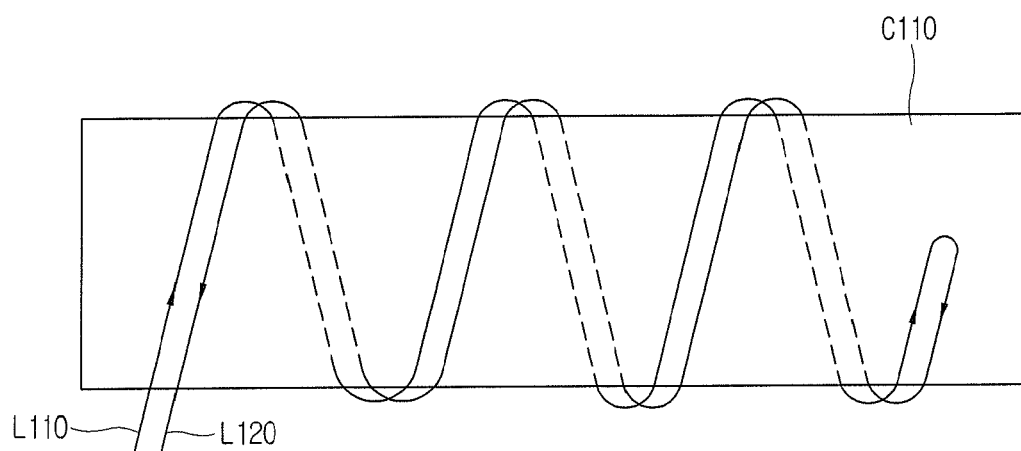


FIG. 23

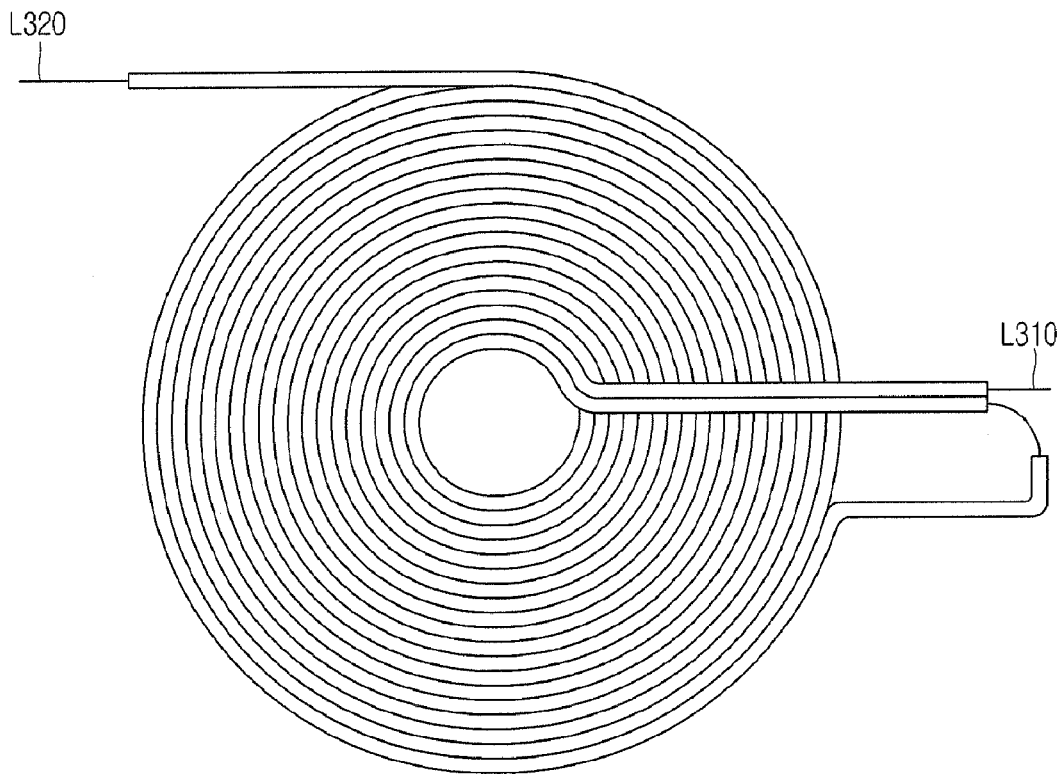


FIG. 24

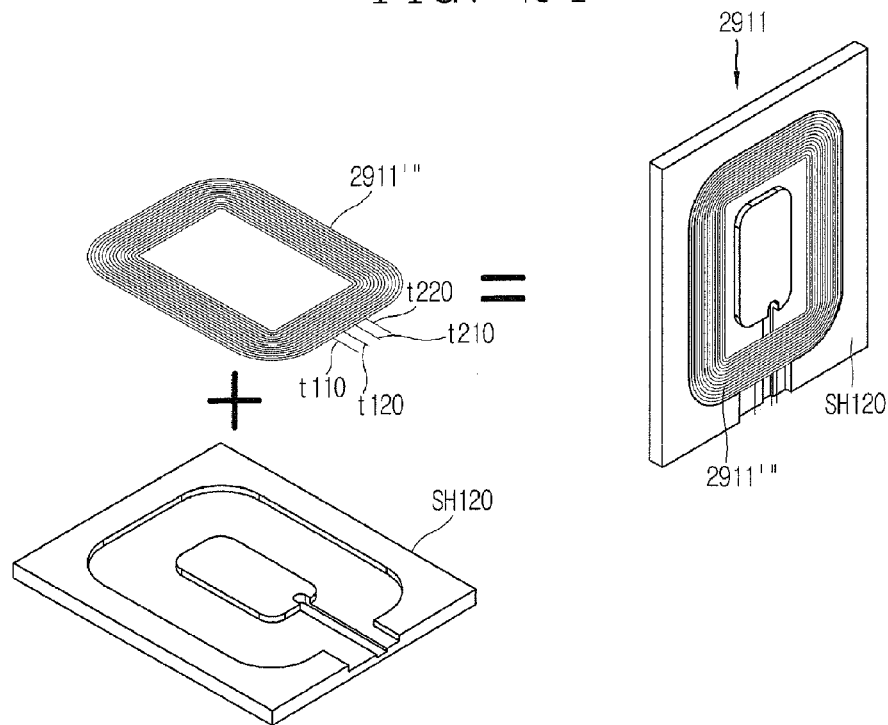


FIG. 25

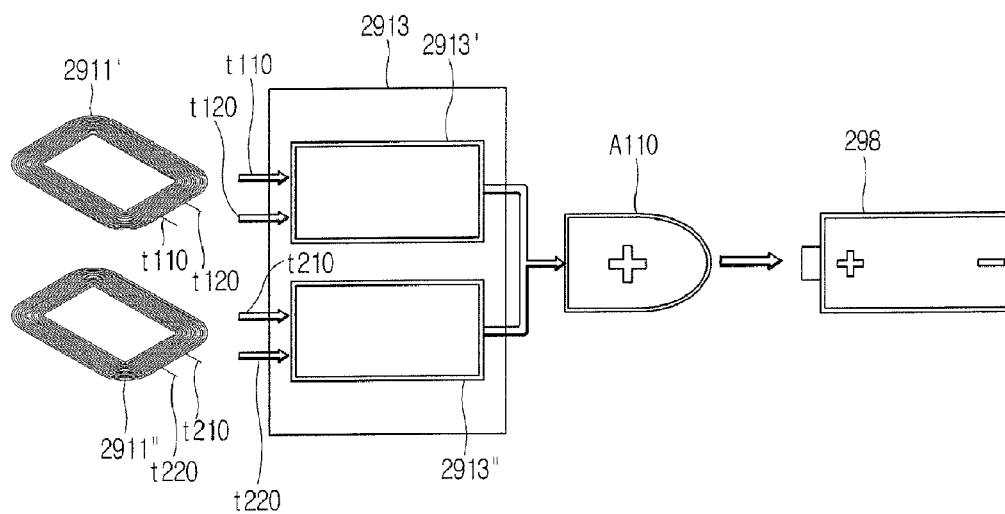


FIG. 26

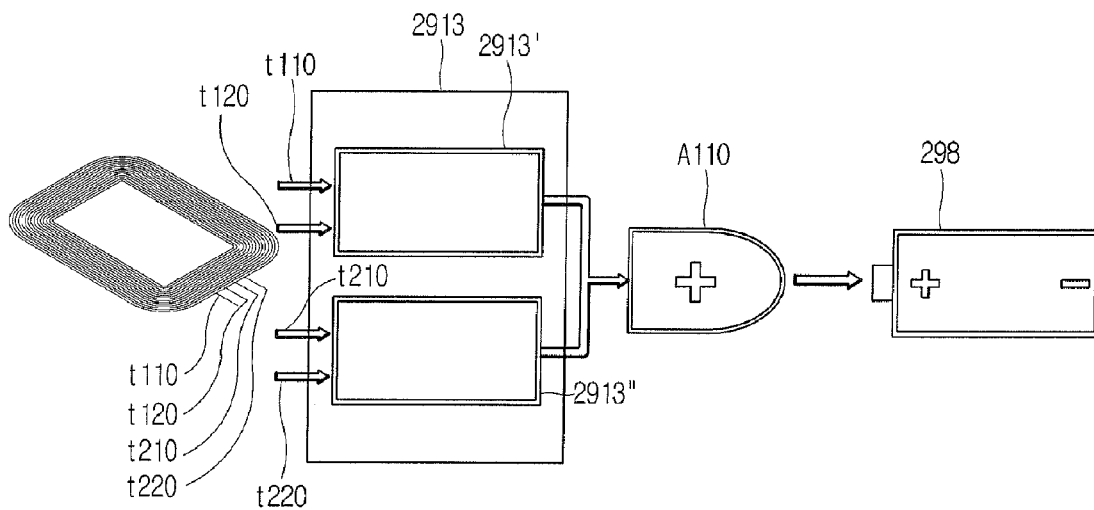


FIG. 27

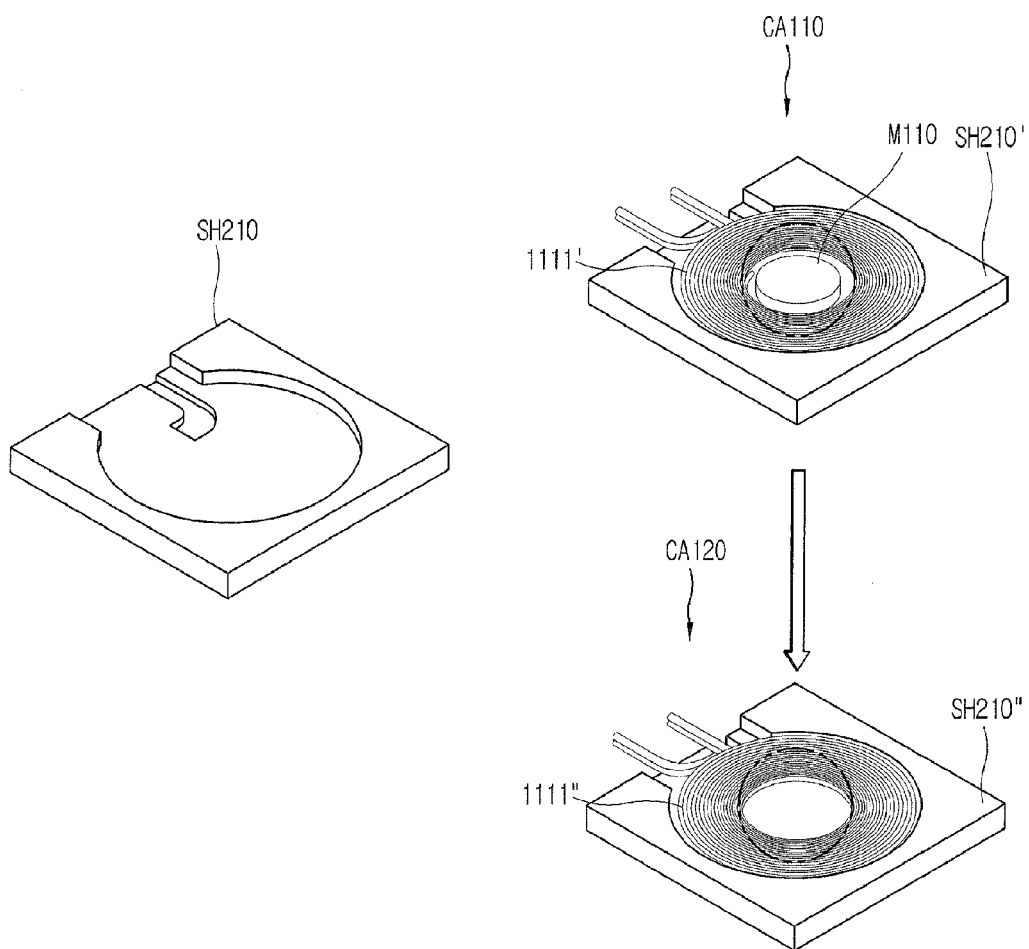
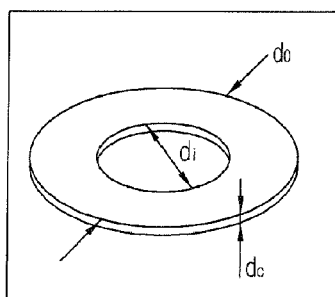


FIG. 28



| PARAMETER                 | SYMBOL | VALUE                     |
|---------------------------|--------|---------------------------|
| OUTER DIAMETER            | $d_o$  | $43 \pm 0.5 \text{ mm}$   |
| INNER DIAMETER            | $d_i$  | $20.5 \pm 0.5 \text{ mm}$ |
| THICKNESS                 | $d_c$  | $2.1 \pm 0.5 \text{ mm}$  |
| NUMBER OF TURNS PER LAYER | N      | 10 (5 BIFILAR TURNS)      |
| NUMBER OF LAYERS          | -      | 2                         |

FIG. 29

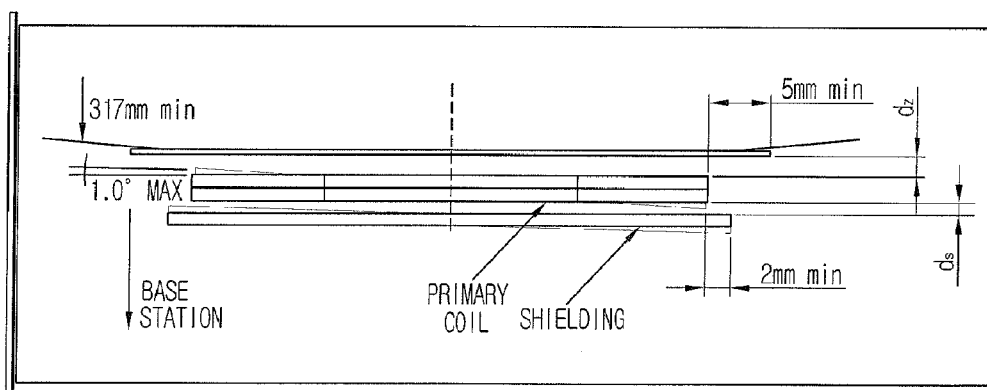


FIG. 30

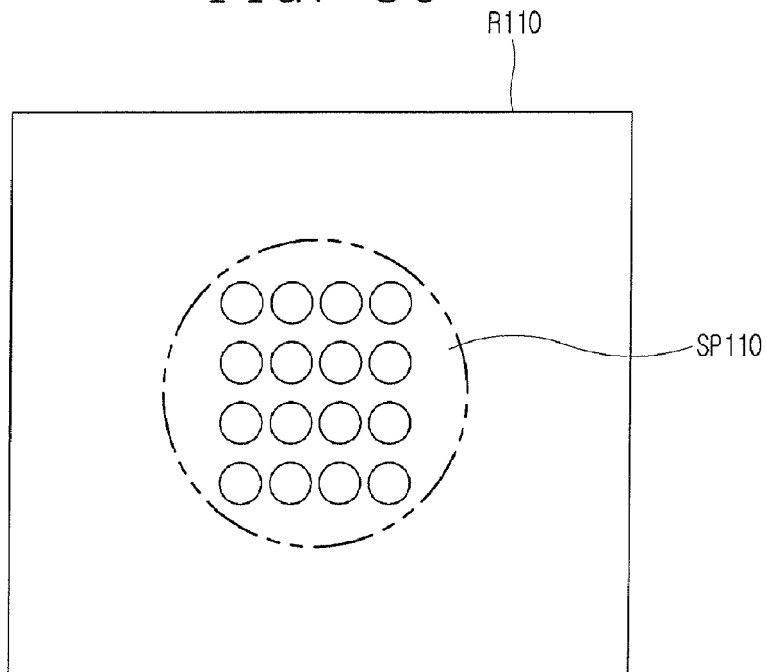


FIG. 31

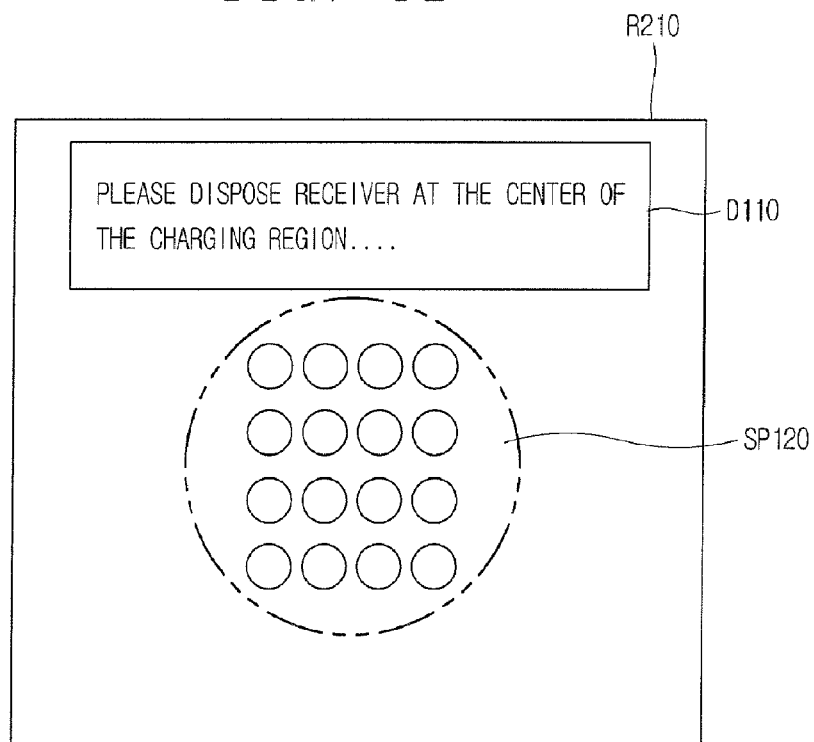
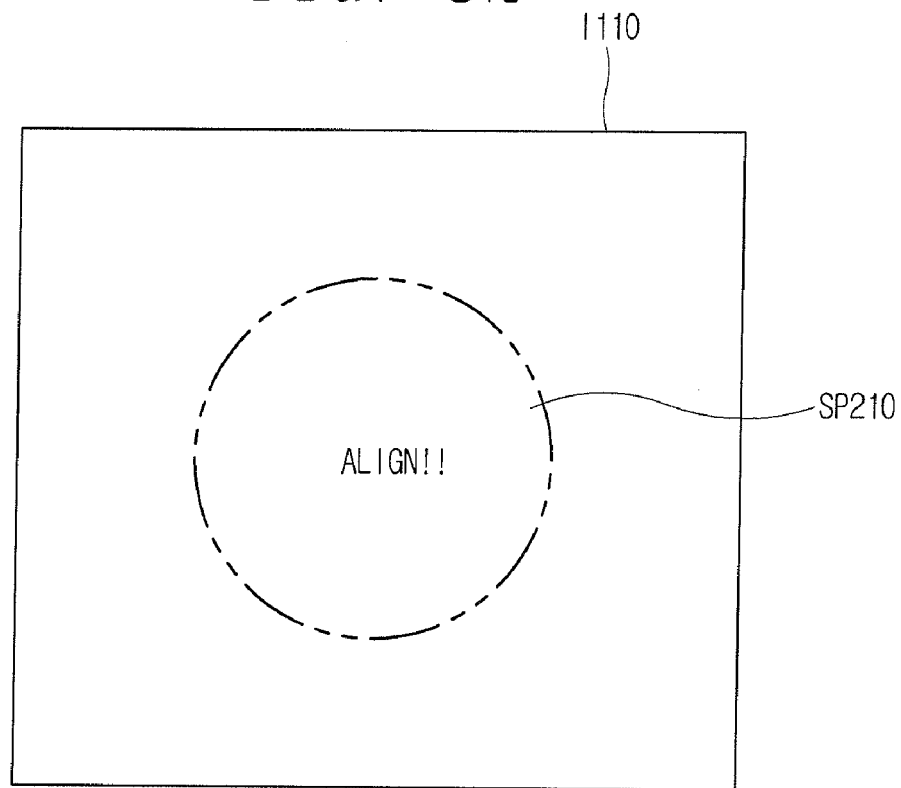


FIG. 32



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## STRUCTURE OF TRANSMISSION AND RECEPTION UNIT IN WIRELESS CHARGING SYSTEM

### RELATED APPLICATION

Pursuant to 35 U.S.C. §119(e), this application claims the benefit of earlier filing date and right of priority to U.S. Provisional Application No. 61/649,739, filed on May 21, 2012, the contents of which is incorporated by reference herein in its entirety.

### BACKGROUND OF THE INVENTION

#### 1. Field of the Invention

The present disclosure relates to wireless charging, and more particularly, wireless charging according to a charging characteristic.

#### 2. Description of the Related Art

In recent years, the method of contactlessly supplying electrical energy to electronic devices in a wireless manner has been used instead of the traditional method of supplying electrical energy in a wired manner. The electronic device receiving energy in a wireless manner may be directly driven by the received wireless power, or a battery may be charged by using the received wireless power, then allowing the electronic device to be driven by the charged power.

### SUMMARY OF THE INVENTION

Therefore, an aspect of this specification is to provide the structure of a transmission and reception unit in a wireless charging system. In particular, there is disclosed a structure of a transmitting coil in the transmission unit of the wireless power transmitter and a receiving coil in the receiving unit of the wireless power receiver.

In order to accomplish the foregoing task, there is provided a wireless power receiver configured to receive a wireless power signal from a wireless power transmitter to receive wireless power, and the wireless power receiver may include a receiving coil unit comprising a primary coil and a secondary coil receiving the wireless power signal; and a charger configured to charge power which is a sum of wireless power received by the primary coil and the secondary coil, respectively, based on the wireless power signal.

As an example associated with the present disclosure, the primary coil may be a coil capable of receiving the wireless power signal as first rated power, and the secondary coil may be a coil capable of receiving the wireless power signal as second rated power.

As an example associated with the present disclosure, the first rated power and the second rated power may be 5 W.

As an example associated with the present disclosure, the primary coil may be formed such that two wires connecting between the first terminal and the second terminal are wound in the form of a bifilar winding, and the secondary coil may be formed such that two wires connecting between the third terminal and the fourth terminal are wound in the form of a bifilar winding.

As an example associated with the present disclosure, the primary coil and the secondary coil may be joined to each other such that their directions for receiving the wireless power signal are identical.

As an example associated with the present disclosure, the primary coil may be formed such that a first wire connecting between the first terminal and the second terminal is wound, and the secondary coil may be formed such that a second wire

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connecting between the third terminal and the fourth terminal is wound, and the first wire and the second wire may be wound together in the form of a bifilar winding.

As an example associated with the present disclosure, the wireless power receiver may further include a rectifier unit configured to convert an alternating current signal generated by the primary coil and the secondary coil into a direct current signal based on the wireless power signal, wherein the charger charges power which is a sum of wireless power received by the primary coil and the secondary coil, respectively, based on the direct current signal.

As an example associated with the present disclosure, the rectifier unit may include a first rectifier circuit configured to convert a first alternating current signal generated by the primary coil into a first direct current signal and a second rectifier circuit configured to convert a second alternating current signal generated by the secondary coil into a second direct current signal, and the charger may charge power which is a sum of wireless power received by the primary coil and the secondary coil, respectively, based on the first direct current signal and the second direct current signal.

In order to accomplish the foregoing task, there is provided a wireless power transmitter configured to generate a wireless power signal through a transmitting (Tx) coil assembly to transfer wireless power to a wireless power receiver, wherein the transmitting (Tx) coil assembly includes a transmitting coil configured to generate the wireless power signal; and a shielding portion configured to shield transmission in a specific direction of the wireless power signal, and provided with a recessed structure accommodating the transmitting coil, and the transmitting coil is aligned with the receiving coil without a magnet for alignment aid or Align Assistance with the receiving coil of the wireless power receiver.

As an example associated with the present disclosure, the specific direction may be a direction opposite to the direction in which the wireless power signal is transmitted to the receiving coil.

As an example associated with the present disclosure, the wireless power transmitter may further include an auxiliary means for the alignment aid or Align Assistance.

As an example associated with the present disclosure, the auxiliary means may be at least one of a display module for displaying alignment information with the receiving coil, an audio output module, and a haptic module.

As an example associated with the present disclosure, the transmitting (Tx) coil assembly may further include an interface surface facing the receiving coil.

As an example associated with the present disclosure, the auxiliary means may be a marker or lighting means provided on the interface surface for alignment aid with the receiving coil.

In order to accomplish the foregoing task, there is provided a wireless power transmitter configured to generate a wireless power signal through a transmitting (Tx) coil assembly to transfer wireless power to a wireless power receiver, wherein the transmitting (Tx) coil assembly includes a transmitting coil configured to generate the wireless power signal; and a shielding portion configured to shield transmission in a specific direction of the wireless power signal, and provided with a recessed structure accommodating the transmitting coil, and the transmitting coil is aligned with the receiving coil regardless of a magnet for alignment aid or Align Assistance with the receiving coil of the wireless power receiver.

According to a wireless power receiver according to an embodiment disclosed herein, there exists an advantage

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capable of providing a wireless power receiver that can be operated with high rated power using a plurality of receiving coils with low rated power.

Furthermore, according to a wireless power transmitter according to an embodiment disclosed herein, there exists an advantage capable of providing a wireless power transmitter with an enhanced transmission efficiency using a transmitting (Tx) coil assembly from which a magnet for alignment aid is removed.

#### BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings, which are included to provide a further understanding of the invention and are incorporated in and constitute a part of this specification, illustrate embodiments of the invention and together with the description serve to explain the principles of the invention.

In the drawings:

FIG. 1 is an exemplary view conceptually illustrating a wireless power transmitter and an electronic device according to the embodiments of the present invention;

FIGS. 2A and 2B are exemplary block diagrams illustrating the configuration of a wireless power transmitter **100** and an electronic device (or wireless power receiver) **200** that can be employed in the embodiments disclosed herein, respectively;

FIG. 3 is a view illustrating a concept in which power is transferred from a wireless power transmitter to an electronic device in a wireless manner according to an inductive coupling method;

FIGS. 4A and 4B are a block diagram illustrating part of the wireless power transmitter **100** and electronic device (or wireless power receiver) **200** in a magnetic induction method that can be employed in the embodiments disclosed herein;

FIG. 5 is a block diagram illustrating a wireless power transmitter configured to have one or more transmission coils receiving power according to an inductive coupling method that can be employed in the embodiments disclosed herein;

FIG. 6 is a view illustrating a concept in which power is transferred to an electronic device from a wireless power transmitter in a wireless manner according to a resonance coupling method;

FIGS. 7A and 7B are a block diagram illustrating part of the wireless power transmitter **100** and electronic device (or wireless power receiver) **200** in a resonance method that can be employed in the embodiments disclosed herein;

FIG. 8 is a block diagram illustrating a wireless power transmitter configured to have one or more transmission coils receiving power according to a resonance coupling method that can be employed in the embodiments disclosed herein;

FIG. 9 is a block diagram illustrating a wireless power transmitter further including an additional element in addition to the configuration illustrated in FIG. 2A;

FIG. 10 is view illustrating a configuration in case where an electronic device (or wireless power receiver) **200** according to the embodiments disclosed herein is implemented in the form of a mobile terminal;

FIGS. 11A and 11B are a view illustrating the concept of transmitting and receiving a packet between a wireless power transmitter and an electronic device through the modulation and demodulation of a wireless power signal in transferring power in a wireless manner disclosed herein;

FIGS. 12A and 12B is a view illustrating a method of showing data bits and byte constituting a power control message provided by the wireless power transmitter **100**;

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FIG. 13 is a view illustrating a packet including a power control message used in a contactless (wireless) power transfer method according to the embodiments disclosed herein;

FIG. 14 is a view illustrating the operation phases of the wireless power transmitter **100** and electronic device (or wireless power receiver) **200** according to the embodiments disclosed herein;

FIGS. 15 through 19 are views illustrating the structure of packets including a power control message between the wireless power transmitter **100** and electronic device (or wireless power receiver) **200**;

FIG. 20 is a configuration view illustrating a wireless power receiver according to an embodiment disclosed herein;

FIG. 21 is an exemplary view illustrating a receiving coil unit according to an embodiment disclosed herein;

FIG. 22 is an exemplary view illustrating a bifilar winding according to an embodiment disclosed herein;

FIG. 23 is another exemplary view illustrating a bifilar winding according to another embodiment disclosed herein;

FIG. 24 is a view illustrating the structure of a receiving coil unit according to another embodiment disclosed herein;

FIG. 25 is an exemplary view illustrating a wireless power receiver according to an embodiment disclosed herein;

FIG. 26 is an exemplary view illustrating a wireless power receiver according to another embodiment disclosed herein;

FIG. 27 is an exemplary view illustrating the structure of a transmitting (Tx) coil assembly according to an embodiment disclosed herein;

FIG. 28 is an exemplary view illustrating the standard of a transmitting coil according to an embodiment disclosed herein;

FIG. 29 is an exemplary view illustrating the standard of a transmitting (Tx) coil assembly according to an embodiment disclosed herein;

FIG. 30 is an exemplary view illustrating an auxiliary means for alignment aid or Align Assistance according to an embodiment disclosed herein;

FIG. 31 is an exemplary view illustrating an auxiliary means for alignment aid or Align Assistance according to another embodiment disclosed herein; and

FIG. 32 is an exemplary view illustrating an auxiliary means for alignment aid or Align Assistance according to still another embodiment disclosed herein.

#### DETAILED DESCRIPTION OF THE INVENTION

The technologies disclosed herein may be applicable to wireless power transfer (contactless power transfer). However, the technologies disclosed herein are not limited to this, and may be also applicable to all kinds of power transmission systems and methods, wireless charging circuits and methods to which the technological spirit of the technology can be applicable, in addition to the methods and apparatuses using power transmitted in a wireless manner. It should be noted that technological terms used herein are merely used to describe a specific embodiment, but not to limit the present invention. Also, unless to particularly defined otherwise, technological terms used herein should be construed as a meaning that is generally understood by those having ordinary skill in the art to which the invention pertains, and should not be construed too broadly or too narrowly. Furthermore, if technological terms used herein are wrong terms unable to correctly express the spirit of the invention, then they should be replaced by technological terms that are properly understood by those skilled in the art. In addition, general terms used in this invention should be construed based on the defi-

inition of dictionary, or the context, and should not be construed too broadly or too narrowly.

Incidentally, unless clearly used otherwise, expressions in the singular number include a plural meaning. In this application, the terms “comprising” and “including” should not be construed to necessarily include all of the elements or steps disclosed herein, and should be construed not to include some of the elements or steps thereof, or should be construed to further include additional elements or steps.

In addition, a suffix “module” or “unit” used for constituent elements disclosed in the following description is merely intended for easy description of the specification, and the suffix itself does not give any special meaning or function. Furthermore, the terms including an ordinal number such as first, second, etc. can be used to describe various elements, but the elements should not be limited by those terms. The terms are used merely for the purpose to distinguish an element from the other element. For example, a first element may be named to a second element, and similarly, a second element may be named to a first element without departing from the scope of right of the invention.

Hereinafter, preferred embodiments of the present invention will be described in detail with reference to the accompanying drawings, and the same or similar elements are designated with the same numeral references regardless of the numerals in the drawings and their redundant description will be omitted.

In describing the present invention, moreover, the detailed description will be omitted when a specific description for publicly known technologies to which the invention pertains is judged to obscure the gist of the present invention. Also, it should be noted that the accompanying drawings are merely illustrated to easily explain the spirit of the invention, and therefore, they should not be construed to limit the spirit of the invention by the accompanying drawings.

FIG. 1—Conceptual View of Wireless Power Transmitter and Electronic Device

FIG. 1 is an exemplary view conceptually illustrating a wireless power transmitter and an electronic device according to the embodiments of the present invention. Referring to FIG. 1, the wireless power transmitter **100** may be a power transfer apparatus configured to transfer power required for the electronic device (or wireless power receiver) **200** in a wireless manner.

Furthermore, the wireless power transmitter **100** may be a wireless charging apparatus configured to charge a battery of the electronic device (or wireless power receiver) **200** by transferring power in a wireless manner. A case where the wireless power transmitter **100** is a wireless charging apparatus will be described later with reference to FIG. 9.

Additionally, the wireless power transmitter **100** may be implemented with various forms of apparatuses transferring power to the electronic device (or wireless power receiver) **200** requiring power in a contactless state.

The electronic device (or wireless power receiver) **200** is a device that is operable by receiving power from the wireless power transmitter **100** in a wireless manner. Furthermore, the electronic device (or wireless power receiver) **200** may charge a battery using the received wireless power.

On the other hand, an electronic device for receiving power in a wireless manner as described herein should be construed broadly to include a portable phone, a cellular phone, a smart phone, a personal digital assistant (PDA), a portable multimedia player (PMP), a tablet, a multimedia device, or the like, in addition to an input/output device such as a keyboard, a mouse, an audio-visual auxiliary device, and the like.

The electronic device (or wireless power receiver) **200**, as described later, may be a mobile communication terminal, (for example, a portable phone, a cellular phone, and a tablet or multimedia device). In case where the electronic device is a mobile terminal, it will be described later with reference to FIG. 10.

On the other hand, the wireless power transmitter **100** may transfer power in a wireless manner without mutual contact to the electronic device (or wireless power receiver) **200** using one or more wireless power transfer methods. In other words, the wireless power transmitter **100** may transfer power using at least one of an inductive coupling method based on magnetic induction phenomenon by the wireless power signal and a magnetic resonance coupling method based on electromagnetic resonance phenomenon by a wireless power signal at a specific frequency.

Wireless power transfer in the inductive coupling method is a technology transferring power in a wireless manner using a primary coil and a secondary coil, and refers to the transmission of power by inducing a current from a coil to another coil through a changing magnetic field by a magnetic induction phenomenon. Wireless power transfer in the inductive coupling method refers to a technology in which the electronic device (or wireless power receiver) **200** generates resonance by a wireless power signal transmitted from the wireless power transmitter **100** to transfer power from the wireless power transmitter **100** to the wireless power receiver **200** by the resonance phenomenon.

Hereinafter, the wireless power transmitter **100** and electronic device (or wireless power receiver) **200** according to the embodiments disclosed herein will be described in detail. In assigning reference numerals to the constituent elements in each of the following drawings, the same reference numerals will be used for the same constituent elements even though they are shown in a different drawing.

FIGS. 2A and 2B are an exemplary block diagrams illustrating the configuration of a wireless power transmitter **100** and an electronic device (or wireless power receiver) **200** that can be employed in the embodiments disclosed herein.

FIG. 2A—Wireless Power Transmitter

Referring to FIG. 2A, the wireless power transmitter **100** may include a power transmission unit **110**. The power transmission unit **110** may include a power conversion unit **111** and a power transmission control unit **112**.

The power conversion unit **111** transfers power supplied from a transmission side power supply unit **190** to the electronic device (or wireless power receiver) **200** by converting it into a wireless power signal. The wireless power signal transferred by the power conversion unit **111** is generated in the form of a magnetic field or electro-magnetic field having an oscillation characteristic. For this purpose, the power conversion unit **111** may be configured to include a coil for generating the wireless power signal.

The power conversion unit **111** may include a constituent element for generating a different type of wireless power signal according to each power transfer method. In accordance with exemplary embodiments, the power conversion unit **111** may include a primary coil for forming a changing magnetic field to induce a current to a secondary coil of the electronic device (or wireless power receiver) **200**. Furthermore, the power conversion unit **111** may include a coil (or antenna) for forming a magnetic field having a specific resonant frequency to generate a resonant frequency in the electronic device (or wireless power receiver) **200** according to the resonance coupling method.

Furthermore, the power conversion unit **111** may transfer power using at least one of the foregoing inductive coupling

method and the resonance coupling method. Among the constituent elements included in the power conversion unit **111**, those for the inductive coupling method will be described later with reference to FIGS. **4** and **5**, and those for the resonance coupling method will be described with reference to FIGS. **7** and **8**.

On the other hand, the power conversion unit **111** may further include a circuit for controlling the characteristics of a used frequency, an applied voltage, an applied current or the like to form the wireless power signal.

The power transmission control unit **112** controls each of the constituent elements included in the power transmission unit **110**. The power transmission control unit **112** may be implemented to be integrated into another control unit (not shown) for controlling the wireless power transmitter **100**.

On the other hand, a region to which the wireless power signal can be approached may be divided into two types. First, an active area denotes a region through which a wireless power signal transferring power to the electronic device (or wireless power receiver) **200** is passed. Next, a semi-active area denotes an interest region in which the wireless power transmitter **100** can detect the existence of the electronic device (or wireless power receiver) **200**. Here, the power transmission control unit **112** may detect whether the electronic device (or wireless power receiver) **200** is placed in the active area or detection area or removed from the area. Specifically, the power transmission control unit **112** may detect whether or not the electronic device (or wireless power receiver) **200** is placed in the active area or detection area using a wireless power signal formed from the power conversion unit **111** or a sensor separately provided therein. For instance, the power transmission control unit **112** may detect the presence of the electronic device (or wireless power receiver) **200** by monitoring whether or not the characteristic of power for forming the wireless power signal is changed by the wireless power signal, which is affected by the electronic device (or wireless power receiver) **200** existing in the detection area. However, the active area and detection area may vary according to the wireless power transfer method such as an inductive coupling method, a resonance coupling method, and the like.

The power transmission control unit **112** may perform the process of identifying the electronic device (or wireless power receiver) **200** or determine whether to start wireless power transfer according to a result of detecting the existence of the electronic device (or wireless power receiver) **200**.

Furthermore, the power transmission control unit **112** may determine at least one characteristic of a frequency, a voltage, and a current of the power conversion unit **111** for forming the wireless power signal. The determination of the characteristic may be carried out by a condition at the side of the wireless power transmitter **100** or a condition at the side of the electronic device (or wireless power receiver) **200**. In exemplary embodiments, the power transmission control unit **112** may decide the characteristic based on device identification information. In another exemplary embodiment, the power transmission control unit **112** may decide the characteristic based on required power information of the electronic device (or wireless power receiver) **200** or profile information related to the required power. The power transmission control unit **112** may receive a power control message from the electronic device (or wireless power receiver) **200**. The power transmission control unit **112** may determine at least one characteristic of a frequency, a voltage and a current of the power conversion unit **111** based on the received power control message, and additionally perform other control operations based on the power control message.

For example, the power transmission control unit **112** may determine at least one characteristic of a frequency, a voltage and a current used to form the wireless power signal according to the power control message including at least one of rectified power amount information, charging state information and identification information in the electronic device (or wireless power receiver) **200**.

Furthermore, as another control operation using the power control message, the wireless power transmitter **100** may perform a typical control operation associated with wireless power transfer based on the power control message. For example, the wireless power transmitter **100** may receive information associated with the electronic device (or wireless power receiver) **200** to be auditorily or visually outputted through the power control message, or receive information required for authentication between devices.

In exemplary embodiments, the power transmission control unit **112** may receive the power control message through the wireless power signal. In other exemplary embodiment, the power transmission control unit **112** may receive the power control message through a method for receiving user data.

In order to receive the foregoing power control message, the wireless power transmitter **100** may further include a modulation/demodulation unit **113** electrically connected to the power conversion unit **111**. The modulation/demodulation unit **113** may modulate a wireless power signal that has been modulated by the electronic device (or wireless power receiver) **200** and use it to receive the power control message. The method for allowing the power conversion unit **111** to receive a power control message using a wireless power signal will be described later with reference to FIGS. **11** through **13**.

In addition, the power transmission control unit **112** may acquire a power control message by receiving user data including a power control message by a communication means (not shown) included in the wireless power transmitter **100**.

In accordance with one exemplary embodiment, the wireless power transmitter **100** may supply power to a plurality of electronic devices. Here, collision may occur between wireless power signal which have been modulated by the plurality of electronic devices. Hence, the constituent elements included in the wireless power transmitter **100** may perform various operations to avoid such collision between the modulated wireless power signal.

In one exemplary embodiment, the power conversion unit **111** may convert power supplied from the transmission side power supply unit **190** into a wireless power signal and transfer it to the plurality of electronic devices. For example, the plurality of electronic devices may be two electronic devices, namely, a first electronic device and a second electronic device.

The power conversion unit **111** may generate a wireless power signal for power transmission, and receive a first response signal and a second response signal corresponding to the wireless power signal.

The power transmission control unit **112** may determine whether or not the first and second response signals collide with each other. When the first and second response signals collide with each other according to the determination result, the power transmission control unit **112** may reset the power transmission.

The first and second response signals may be generated by modulating the wireless power signal through the first and second electronic devices.

Through the resetting of the power transmission, the power transmission control unit **112** may control the power conversion unit **111** to sequentially receive the first and second response signals, which are generated to avoid collision with each other.

The sequential reception indicates that the first response signal is received after a first time interval and the second response signal is received after a second time interval within a predetermined response period. The first and second time intervals may be decided based on a value obtained by generating a random number.

The predetermined response period (Tping interval) may be decided to be long enough to include both the first response signal and the second response signal. Also, it may be decided after resetting the power transmission.

In accordance with one exemplary embodiment, occurrence or non-occurrence of the collision may be determined according to whether or not the first and second response signals are decoded using a preset format. The preset format may include a preamble, a header and a message. Whether or not the first and second response signals collide with each other may be determined based on whether or not the first and second response signals are not recoverable due to an error generation in at least one of the preamble, the header and the message caused by the collision.

In accordance with one exemplary embodiment, the power conversion unit **111** may periodically receive a response signal of the first device, which does not collide with a response signal of the second device within a first response period (Tping interval<sub>1</sub>). The power transmission control unit may decode the first response signal and the second response signal using a preset format, and determine whether or not the first and second response signals have collided with each other based on whether or not the decoding is performed. Here, the first response signal and the second response signal may be periodically received within a second response period (Tping interval<sub>2</sub>). The second response period (Tping interval<sub>2</sub>) may be decided long enough to include both the first and second response signals, and be decided after resetting the power transmission.

#### FIG. 2B—Electronic Device

Referring to FIG. 2B, the electronic device (or wireless power receiver) **200** may include a power supply unit **290**. The power supply unit **290** supplies power required for the operation of the electronic device (or wireless power receiver) **200**. The power supply unit **290** may include a power receiving unit **291** and a Power reception control unit (or POWER RECEIVING CONTROL UNIT) **292**.

The power receiving unit **291** receives power transferred from the wireless power transmitter **100** in a wireless manner.

The power receiving unit **291** may include constituent elements required to receive the wireless power signal according to a wireless power transfer method. Furthermore, the power receiving unit **291** may receive power according to at least one wireless power transfer method, and in this case, the power receiving unit **291** may include constituent elements required for each method.

First, the power receiving unit **291** may include a coil for receiving a wireless power signal transferred in the form of a magnetic field or electromagnetic field having a vibration characteristic.

For instance, as a constituent element according to the inductive coupling method, the power receiving unit **291** may include a secondary coil to which a current is induced by a changing magnetic field. In exemplary embodiments, the power receiving unit **291**, as a constituent element according to the resonance coupling method, may include a coil and a

resonant circuit in which resonance phenomenon is generated by a magnetic field having a specific resonant frequency.

In another exemplary embodiments, when the power receiving unit **291** receives power according to at least one wireless power transfer method, the power receiving unit **291** may be implemented to receive power by using a coil, or implemented to receive power by using a coil formed differently according to each power transfer method.

Among the constituent elements included in the power receiving unit **291**, those for the inductive coupling method will be described later with reference to FIGS. 4A and 4B, and those for the resonance coupling method with reference to FIGS. 7A and 7B.

On the other hand, the power receiving unit **291** may further include a rectifier and a regulator to convert the wireless power signal into a direct current. Furthermore, the power receiving unit **291** may further include a circuit for protecting an overvoltage or overcurrent from being generated by the received power signal.

The Power reception control unit (or POWER RECEIVING CONTROL UNIT) **292** may control each constituent element included in the power supply unit **290**. Specifically, the Power reception control unit (or POWER RECEIVING CONTROL UNIT) **292** may transfer a power control message to the wireless power transmitter **100**. The power control message may instruct the wireless power transmitter **100** to initiate or terminate a transfer of the wireless power signal. Furthermore, the power control message may instruct the wireless power transmitter **100** to control a characteristic of the wireless power signal.

In exemplary embodiments, the Power reception control unit (or POWER RECEIVING CONTROL UNIT) **292** may transmit the power control message through the wireless power signal. In another exemplary embodiment, the Power reception control unit (or POWER RECEIVING CONTROL UNIT) **292** may transmit the power control message through a method for transmitting user data.

In order to transmit the foregoing power control message, the electronic device (or wireless power receiver) **200** may further include a modulation/demodulation unit **293** electrically connected to the power receiving unit **291**. The modulation/demodulation unit **293**, similarly to the case of the wireless power transmitter **100**, may be used to transmit the power control message through the wireless power signal. The power communications modulation/demodulation unit **293** may be used as a means for controlling a current and/or voltage flowing through the power conversion unit **111** of the wireless power transmitter **100**. Hereinafter, a method for allowing the power communications modulation/demodulation unit **113** or **293** at the side of the wireless power transmitter **100** and at the side of the electronic device (or wireless power receiver) **200**, respectively, to be used to transmit and receive a power control message through a wireless power signal will be described.

A wireless power signal formed by the power conversion unit **111** is received by the power receiving unit **291**. At this time, the Power reception control unit (or POWER RECEIVING CONTROL UNIT) **292** controls the power communications modulation/demodulation unit **293** at the side of the electronic device (or wireless power receiver) **200** to modulate the wireless power signal. For instance, the Power reception control unit (or POWER RECEIVING CONTROL UNIT) **292** may perform a modulation process such that a power amount received from the wireless power signal is varied by changing a reactance of the power communications modulation/demodulation unit **293** connected to the power receiving unit **291**. The change of a power amount received

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from the wireless power signal results in the change of a current and/or voltage of the power conversion unit **111** for forming the wireless power signal. At this time, the modulation/demodulation unit **113** at the side of the wireless power transmitter **100** may detect a change of the current and/or voltage to perform a demodulation process.

In other words, the Power reception control unit (or POWER RECEIVING CONTROL UNIT) **292** may generate a packet including a power control message intended to be transferred to the wireless power transmitter **100** and modulate the wireless power signal to allow the packet to be included therein, and the power transmission control unit **112** may decode the packet based on a result of performing the demodulation process of the power communications modulation/demodulation unit **113** to acquire the power control message included in the packet. The detailed method of allowing the wireless power transmitter **100** to acquire the power control message will be described later with reference to FIGS. **11** through **13**.

In addition, the Power reception control unit (or POWER RECEIVING CONTROL UNIT) **292** may transmit a power control message to the wireless power transmitter **100** by transmitting user data including the power control message by a communication means (not shown) included in the electronic device (or wireless power receiver) **200**.

In addition, the power supply unit **290** may further include a charger (or charging unit) **298** and a battery **299**.

The electronic device (or wireless power receiver) **200** receiving power for operation from the power supply unit **290** may be operated by power transferred from the wireless power transmitter **100**, or operated by charging the battery **299** using the transferred power and then receiving the charged power. At this time, the Power reception control unit (or POWER RECEIVING CONTROL UNIT) **292** may control the charger (or charging unit) **298** to perform charging using the transferred power.

In one exemplary embodiment, the plurality of electronic devices may receive power from the wireless power transmitter **100**. Here, collision may occur between wireless power signal which have been modulated by the plurality of electronic devices. Hence, the constituent elements included in the wireless power transmitter **100** may perform various operations to avoid such collision between the modulated wireless power signal.

In one exemplary embodiment, the power receiving unit **291** may receive the wireless power signal for the power transmission from the wireless power transmitter.

Here, the Power reception control unit (or POWER RECEIVING CONTROL UNIT) **292** may control the power receiving unit **291** to transmit a third response signal corresponding to the wireless power signal after a time interval set to a first time within the first response period (Tping interval\_1).

In one exemplary embodiment, the Power reception control unit (or POWER RECEIVING CONTROL UNIT) **292** may determine whether or not the power transmission of the wireless power transmitter **100** has been reset due to collision between the modulated wireless power signal, and set the time interval to a second time when the power transmission has been reset according to the determination result.

In one exemplary embodiment, the Power reception control unit (or POWER RECEIVING CONTROL UNIT) **292** may control the power receiving unit **291** to transmit a fourth response signal corresponding to the wireless power signal after the time interval set to the second time within the second response period (Tping interval\_2). The second time may be decided by a value obtained by generating a random number.

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Hereinafter, a wireless power transmitter and an electronic device applicable to the embodiments disclosed herein will be described.

First, a method of allowing the wireless power transmitter to transfer power to the electronic device according to the inductive coupling method will be described with reference to FIGS. **3** through **5**.

#### FIG. 3—Inductive Coupling Method

FIG. **3** is a view illustrating a concept in which power is transferred from a wireless power transmitter to an electronic device in a wireless manner according to an inductive coupling method.

When the power of the wireless power transmitter **100** is transferred in an inductive coupling method, if the strength of a current flowing through a primary coil within the power transmission unit **110** is changed, then a magnetic field passing through the primary coil will be changed by the current. The changed magnetic field generates an induced electromotive force at a secondary coil in the electronic device (or wireless power receiver) **200**.

According to the foregoing method, the power conversion unit **111** of the wireless power transmitter **100** may include a transmitting (Tx) coil **111a** being operated as a primary coil in magnetic induction. Furthermore, the power receiving unit **291** of the electronic device (or wireless power receiver) **200** may include a receiving (Rx) coil **291a** being operated as a secondary coil in magnetic induction.

First, the wireless power transmitter **100** and electronic device (or wireless power receiver) **200** are disposed in such a manner that the transmitting (Tx) coil **111a** at the side of the wireless power transmitter **100** and the receiving coil at the side of the electronic device (or wireless power receiver) **200** are located adjacent to each other. Then, if the power transmission control unit **112** controls a current of the transmitting (Tx) coil **111a** to be changed, then the power receiving unit **291** controls power to be supplied to the electronic device (or wireless power receiver) **200** using an electromotive force induced to the receiving (Rx) coil **291a**.

The efficiency of wireless power transfer by the inductive coupling method may be little affected by a frequency characteristic, but affected by an alignment and distance between the wireless power transmitter **100** and the electronic device (or wireless power receiver) **200** including each coil.

On the other hand, in order to perform wireless power transfer in the inductive coupling method, the wireless power transmitter **100** may be configured to include an interface surface (not shown) in the form of a flat surface. One or more electronic devices may be placed at an upper portion of the interface surface, and the transmitting (Tx) coil **111a** may be mounted at a lower portion of the interface surface. In this case, a vertical spacing is formed in a small-scale between the transmitting (Tx) coil **111a** mounted at a lower portion of the interface surface and the receiving (Rx) coil **291a** of the electronic device (or wireless power receiver) **200** placed at an upper portion of the interface surface, and thus a distance between the coils becomes sufficiently small to efficiently implement contactless power transfer by the inductive coupling method.

Furthermore, an alignment indicator (not shown) indicating a location where the electronic device (or wireless power receiver) **200** is to be placed at an upper portion of the interface surface. The alignment indicator indicates a location of the electronic device (or wireless power receiver) **200** where an alignment between the transmitting (Tx) coil **111a** mounted at a lower portion of the interface surface and the receiving (Rx) coil **291a** can be suitably implemented. The alignment indicator may alternatively be simple marks, or

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may be formed in the form of a protrusion structure for guiding the location of the electronic device (or wireless power receiver) **200**. Otherwise, the alignment indicator may be formed in the form of a magnetic body such as a magnet mounted at a lower portion of the interface surface, thereby guiding the coils to be suitably arranged by mutual magnetism to a magnetic body having an opposite polarity mounted within the electronic device (or wireless power receiver) **200**.

On the other hand, the wireless power transmitter **100** may be formed to include one or more transmitting coils. The wireless power transmitter **100** may selectively use some of coils suitably arranged with the receiving (Rx) coil **2911a** of the electronic device (or wireless power receiver) **200** among the one or more transmitting coils to enhance the power transmission efficiency. The wireless power transmitter **100** including the one or more transmitting coils will be described later with reference to FIG. 5.

Hereinafter, a configuration of the wireless power transmitter and electronic device using an inductive coupling method applicable to the embodiments disclosed herein will be described in detail.

FIGS. 4A and 4B—Wireless Power Transmitter and Electronic Device in Inductive Coupling Method

FIGS. 4A and 4B are a block diagram illustrating part of the wireless power transmitter **100** and electronic device (or wireless power receiver) **200** in a magnetic induction method that can be employed in the embodiments disclosed herein. A configuration of the power transmission unit **110** included in the wireless power transmitter **100** will be described with reference to FIG. 4A, and a configuration of the power supply unit **290** included in the electronic device (or wireless power receiver) **200** will be described with reference to FIG. 4B.

Referring to FIG. 4A, the power conversion unit **111** of the wireless power transmitter **100** may include a transmitting (Tx) coil **1111a** and an inverter **1112**. The transmitting (Tx) coil **1111a** may form a magnetic field corresponding to the wireless power signal according to a change of current as described above. The transmitting (Tx) coil **1111a** may alternatively be implemented with a planar spiral type or cylindrical solenoid type.

The inverter **1112** transforms a DC input obtained from the power supply unit **190** into an AC waveform. The AC current transformed by the inverter **1112** drives a resonant circuit including the transmitting (Tx) coil **1111a** and a capacitor (not shown) to form a magnetic field in the transmitting (Tx) coil **1111a**.

In addition, the power conversion unit **111** may further include a positioning unit **1114**.

The positioning unit **1114** may move or rotate the transmitting (Tx) coil **1111a** to enhance the effectiveness of contactless power transfer using the inductive coupling method. As described above, it is because an alignment and distance between the wireless power transmitter **100** and the electronic device (or wireless power receiver) **200** including a primary coil and a secondary coil may affect power transfer using the inductive coupling method. In particular, the positioning unit **1114** may be used when the electronic device (or wireless power receiver) **200** does not exist within an active area of the wireless power transmitter **100**.

Accordingly, the positioning unit **1114** may include a drive unit (not shown) for moving the transmitting (Tx) coil **1111a** such that a center-to-center distance of the transmitting (Tx) coil **1111a** of the wireless power transmitter **100** and the receiving (Rx) coil **2911a** of the electronic device (or wireless power receiver) **200** is within a predetermined range, or rotating the transmitting (Tx) coil **1111a** such that the centers of

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the transmitting (Tx) coil **1111a** and the receiving (Rx) coil **2911a** are overlapped with each other.

For this purpose, the wireless power transmitter **100** may further include a detection unit (not shown) made of a sensor for detecting the location of the electronic device (or wireless power receiver) **200**, and the power transmission control unit **112** may control the positioning unit **1114** based on the location information of the electronic device (or wireless power receiver) **200** received from the location detection sensor.

Furthermore, to this end, the power transmission control unit **112** may receive control information on an alignment or distance to the electronic device (or wireless power receiver) **200** through the power communications modulation/demodulation unit **113**, and control the positioning unit **1114** based on the received control information on the alignment or distance.

If the power conversion unit **111** is configured to include a plurality of transmitting coils, then the positioning unit **1114** may determine which one of the plurality of transmitting coils is to be used for power transmission. The configuration of the wireless power transmitter **100** including the plurality of transmitting coils will be described later with reference to FIG. 5.

On the other hand, the power conversion unit **111** may further include a power sensing unit **1115**. The power sensing unit **1115** at the side of the wireless power transmitter **100** monitors a current or voltage flowing into the transmitting (Tx) coil **1111a**. The power sensing unit **1115** is provided to check whether or not the wireless power transmitter **100** is normally operated, and thus the power sensing unit **1115** may detect a voltage or current of the power supplied from the outside, and check whether the detected voltage or current exceeds a threshold value. The power sensing unit **1115**, although not shown, may include a resistor for detecting a voltage or current of the power supplied from the outside and a comparator for comparing a voltage value or current value of the detected power with a threshold value to output the comparison result. Based on the check result of the power sensing unit **1115**, the power transmission control unit **112** may control a switching unit (not shown) to cut off power applied to the transmitting (Tx) coil **1111a**.

Referring to FIG. 4B, the power supply unit **290** of the electronic device (or wireless power receiver) **200** may include a receiving (Rx) coil **2911a** and a rectifier (or rectifying) circuit **2913**.

A current is induced into the receiving (Rx) coil **2911a** by a change of the magnetic field formed in the transmitting (Tx) coil **1111a**. The implementation type of the receiving (Rx) coil **2911a** may be a planar spiral type or cylindrical solenoid type similarly to the transmitting (Tx) coil **1111a**.

Furthermore, series and parallel capacitors may be configured to be connected to the receiving (Rx) coil **2911a** to enhance the effectiveness of wireless power reception or perform resonant detection.

The receiving (Rx) coil **2911a** may be in the form of a single coil or a plurality of coils.

The rectifier (or rectifying) circuit **2913** performs a full-wave rectification to a current to convert alternating current into direct current. The rectifier (or rectifying) circuit **2913**, for instance, may be implemented with a full-bridge rectifier generation circuit made of four diodes or a circuit using active components.

In addition, the rectifier (or rectifying) circuit **2913** may further include a regulator circuit for converting a rectified current into a more flat and stable direct current. Furthermore, the output power of the rectifier (or rectifying) circuit **2913** is supplied to each constituent element of the power supply unit

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290. Furthermore, the rectifier (or rectifying) circuit 2913 may further include a DC-DC converter for converting output DC power into a suitable voltage to adjust it to the power required for each constituent element (for instance, a circuit such as a charger (or charging unit) 298).

The power communications modulation/demodulation unit 293 may be connected to the power receiving unit 291, and may be configured with a resistive element in which resistance varies with respect to direct current, and may be configured with a capacitive element in which reactance varies with respect to alternating current. The Power reception control unit (or POWER RECEIVING CONTROL UNIT) 292 may change the resistance or reactance of the power communications modulation/demodulation unit 293 to modulate a wireless power signal received to is the power receiving unit 291.

On the other hand, the power supply unit 290 may further include a power sensing unit 2914. The power sensing unit 2914 at the side of the electronic device (or wireless power receiver) 200 monitors a voltage and/or current of the power rectified by the rectifier (or rectifying) circuit 2913, and if the voltage and/or current of the rectified power exceeds a threshold value as a result of monitoring, then the Power reception control unit (or POWER RECEIVING CONTROL UNIT) 292 transmits a power control message to the wireless power transmitter 100 to transfer suitable power.

FIG. 5—Wireless Power Transmitter Configured to Include One or More Transmitting Coils

FIG. 5 is a block diagram illustrating a wireless power transmitter configured to have one or more transmission coils receiving power according to an inductive coupling method that can be employed in the embodiments disclosed herein. Referring to FIG. 5, the power conversion unit 111 of the wireless power transmitter 100 according to the embodiments disclosed herein may include one or more transmitting coils 1111a-1 to 1111a-n. The one or more transmitting coils 1111a-1 to 1111a-n may be an array of partly overlapping primary coils. An active area may be determined by some of the one or more transmitting coils.

The one or more transmitting coils 1111a-1 to 1111a-n may be mounted at a lower portion of the interface surface. Furthermore, the power conversion unit 111 may further include a multiplexer 1113 for establishing and releasing the connection of some of the one or more transmitting coils 1111a-1 to 1111a-n.

Upon detecting the location of the electronic device (or wireless power receiver) 200 placed at an upper portion of the interface surface, the power transmission control unit 112 may take the detected location of the electronic device (or wireless power receiver) 200 into consideration to control the multiplexer 1113, thereby allowing coils that can be placed in an inductive coupling relation to the receiving (Rx) coil 2911a of the electronic device (or wireless power receiver) 200 among the one or more transmitting coils 1111a-1 to 1111a-n to be connected to one another.

For this purpose, the power transmission control unit 112 may acquire the location information of the electronic device (or wireless power receiver) 200. For example, the power transmission control unit 112 may acquire the location of the electronic device (or wireless power receiver) 200 on the interface surface by the location detection unit (not shown) provided in the wireless power transmitter 100. For another example, the power transmission control unit 112 may alternatively receive a power control message indicating a strength of the wireless power signal from an object on the interface surface or a power control message indicating the identification information of the object using the one or more

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transmitting coils 1111a-1 to 1111a-n, respectively, and determines whether it is located adjacent to which one of the one or more transmitting coils based on the received result, thereby acquiring the location information of the electronic device (or wireless power receiver) 200.

On the other hand, the active area as part of the interface surface may denote a portion through which a magnetic field with a high efficiency can pass when the wireless power transmitter 100 transfers power to the electronic device (or wireless power receiver) 200 in a wireless manner. At this time, a single transmitting coil or one or a combination of more transmitting coils forming a magnetic field passing through the active area may be designated as a primary cell. Accordingly, the power transmission control unit 112 may determine an active area based on the detected location of the electronic device (or wireless power receiver) 200, and establish the connection of a primary cell corresponding to the active area to control the multiplexer 1113, thereby allowing the receiving (Rx) coil 2911a of the electronic device (or wireless power receiver) 200 and the coils belonging to the primary cell to be placed in an inductive coupling relation.

In the meantime, upon disposing one or more electronic devices 200 on an interface surface of the wireless power transmitter 100, which includes the one or more transmitting coils 1111a-1 to 1111a-n, the power transmission control unit 112 may control the multiplexer 1113 to allow the coils belonging to the primary cell corresponding to the position of each electronic device to be placed in the inductive coupling relation. Accordingly, the wireless power transmitter 100 may generate the wireless power signal using different coils, thereby transferring it to the one or more electronic devices in a wireless manner.

Also, the power transmission control unit 112 may set power having a different characteristic to be supplied to each of the coils corresponding to the electronic devices. Here, the wireless power transmitter 100 may transfer power by differently setting a power transfer scheme, efficiency, characteristic and the like for each electronic device. The power transmission for one or more electronic devices will be described later with reference to FIG. 28.

Furthermore, the power conversion unit 111 may further include an impedance matching unit (not shown) for controlling an impedance to form a resonant circuit with the coils connected thereto.

Hereinafter, a method for allowing a wireless power transmitter to transfer power according to a resonance coupling method will be disclosed with reference to FIGS. 6 through 8.

FIG. 6—Resonance Coupling Method

FIG. 6 is a view illustrating a concept in which power is transferred to an electronic device from a wireless power transmitter in a wireless manner according to an resonance coupling method.

First, resonance will be described in brief as follows. Resonance refers to a phenomenon in which an amplitude of vibration is remarkably increased when periodically receiving an external force having the same frequency as the natural frequency of a vibration system. Resonance is a phenomenon occurring at all kinds of vibrations such as mechanical vibration, electric vibration, and the like. Generally, when exerting a vibratory force to a vibration system from the outside, if the natural frequency thereof is the same as a frequency of the externally applied force, then the vibration becomes strong, thus increasing the width.

With the same principle, when a plurality of vibrating bodies separated from one another within a predetermined distance vibrate at the same frequency, the plurality of vibrating bodies resonate with one another, and in this case, result-

ing in a reduced resistance between the plurality of vibrating bodies. In an electrical circuit, a resonant circuit can be made by using an inductor and a capacitor.

When the wireless power transmitter **100** transfers power according to the inductive coupling method, a magnetic field having a specific vibration frequency is formed by alternating current power in the power transmission unit **110**. If a resonance phenomenon occurs in the electronic device (or wireless power receiver) **200** by the formed magnetic field, then power is generated by the resonance phenomenon in the electronic device (or wireless power receiver) **200**. Describing a principle of the resonance coupling, in general, a method for transferring power by generating an electromagnetic wave exhibits low power transmission efficiency, and may badly affect human bodies due to radiation of the electromagnetic waves and exposure to the electromagnetic waves.

However, if the plurality of vibrating bodies resonate with each other in an electromagnetic manner as aforementioned, extremely high power transmission efficiency may be exhibited due to non affection by adjacent objects except for the vibrating bodies. An energy tunnel may be generated between the plurality of vibrating bodies which resonate with each other in the electromagnetic manner. This may be referred to as energy coupling or energy tail.

The resonance coupling disclosed herein may use an electromagnetic wave having a low frequency. When power is transferred using the electromagnetic wave having the low frequency, only a magnetic field may affect an area located within a single wavelength of the electromagnetic wave. The magnetic resonance may be generated when the wireless power transmitter **100** and the electronic device (or wireless power receiver) **200** are located within the single wavelength of the electromagnetic wave having the low frequency.

Here, in general, human bodies are sensitive to an electric field but tolerant to a magnetic field. Hence, when power is transferred using a magnetic resonance, the human bodies may be badly affected due to being exposed to the electromagnetic wave. Also, as the energy tail is generated in response to the resonance phenomenon, the form of power transmission may exhibit a non-radiative property. Consequently, upon transferring power using such electromagnetic wave, a radiative problem which occurs frequently may be solved.

The resonance coupling method may be a method for transferring power using the electromagnetic wave with the low frequency, as aforementioned. Thus, the transmitting (Tx) coil **111b** of the wireless power transmitter **100** may form a magnetic field or electromagnetic wave for transferring power in principle. However, the resonance coupling method will be described hereinafter from the perspective of a magnetic resonance, namely, a power transmission by a magnetic field.

The resonant frequency may be determined by the following formula in Equation 1. [Equation 1]

Here, the resonant frequency ( $f$ ) is determined by an inductance ( $L$ ) and a capacitance ( $C$ ) in a circuit. In a circuit forming a magnetic field using a coil, the inductance can be determined by a number of turns of the coil, and the like, and the capacitance can be determined by a gap between the coils, an area, and the like. In addition to the coil, a capacitive resonant circuit may be configured to be connected thereto to determine the resonant frequency.

Referring to FIG. 6, when power is transmitted in a wireless manner according to the resonance coupling method, the power conversion unit **111** of the wireless power transmitter **100** may include a transmitting (Tx) coil **111b** in which a magnetic field is formed and a resonant circuit (or RESO-

NANT GENERATION CIRCUIT) **1116** connected to the transmitting (Tx) coil **111b** to determine a specific vibration frequency. The resonant circuit (or RESONANT GENERATION CIRCUIT) **1116** may be implemented by using a capacitive circuit (capacitors), and the specific vibration frequency may be determined based on an inductance of the transmitting (Tx) coil **111b** and a capacitance of the resonant circuit (or RESONANT GENERATION CIRCUIT) **1116**.

The configuration of a circuit element of the resonant circuit (or RESONANT GENERATION CIRCUIT) **1116** may be implemented in various forms such that the power conversion unit **111** forms a magnetic field, and is not limited to a form of being connected in parallel to the transmitting (Tx) coil **111b** as illustrated in FIG. 6. Furthermore, the power receiving unit **291** of the electronic device (or wireless power receiver) **200** may include a resonant circuit (or RESONANT GENERATION CIRCUIT) **2912** and a receiving (Rx) coil **2911b** to generate a resonance phenomenon by a magnetic field formed in the wireless power transmitter **100**. In other words, the resonant circuit (or RESONANT GENERATION CIRCUIT) **2912** may be also implemented by using a capacitive circuit, and the resonant circuit (or RESONANT GENERATION CIRCUIT) **2912** is configured such that a resonant frequency determined based on an inductance of the receiving coil **2911b** and a capacitance of the resonant circuit (or RESONANT GENERATION CIRCUIT) **2912** has the same frequency as a resonant frequency of the formed magnetic field.

The configuration of a circuit element of the resonant circuit (or RESONANT GENERATION CIRCUIT) **2912** may be implemented in various forms such that the power receiving unit **291** generates resonance by a magnetic field, and is not limited to a form of being connected in series to the receiving coil **2911b** as illustrated in FIG. 6.

The specific vibration frequency in the wireless power transmitter **100** may have LTX, CTX, and may be acquired by using the Equation 1. Here, the electronic device (or wireless power receiver) **200** generates resonance when a result of substituting the LRX and CRX of the electronic device (or wireless power receiver) **200** to the Equation 1 is same as the specific vibration frequency.

According to a contactless power transfer method by resonance coupling, when the wireless power transmitter **100** and electronic device (or wireless power receiver) **200** resonate at the same frequency, respectively, an electromagnetic wave is propagated through a short-range magnetic field, and thus there exists no energy transfer between the devices if they have different frequencies.

As a result, an efficiency of contactless power transfer by the resonance coupling method is greatly affected by a frequency characteristic, whereas the effect of an alignment and distance between the wireless power transmitter **100** and the electronic device (or wireless power receiver) **200** including each coil is relatively smaller than the inductive coupling method.

Hereinafter, the configuration of a wireless power transmitter and an electronic device in the resonance coupling method applicable to the embodiments disclosed herein will be described in detail.

FIGS. 7A and 7B—Wireless Power Transmitter in Resonance Coupling Method

FIGS. 7A and 7B is a block diagram illustrating part of the wireless power transmitter **100** and electronic device (or wireless power receiver) **200** in a resonance method that can be employed in the embodiments disclosed herein.

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A configuration of the power transmission unit **110** included in the wireless power transmitter **100** will be described with reference to FIG. 7A.

The power conversion unit **111** of the wireless power transmitter **100** may include a transmitting (Tx) coil **1111b**, an inverter **1112**, and a resonant circuit (or RESONANT GENERATION CIRCUIT) **1116**. The inverter **1112** may be configured to be connected to the transmitting (Tx) coil **1111b** and the resonant circuit (or RESONANT GENERATION CIRCUIT) **1116**.

The transmitting (Tx) coil **1111b** may be mounted separately from the transmitting (Tx) coil **1111a** for transferring power according to the inductive coupling method, but may transfer power in the inductive coupling method and resonance coupling method using one single coil.

The transmitting (Tx) coil **1111b**, as described above, forms a magnetic field for transferring power. The transmitting (Tx) coil **1111b** and the resonant circuit (or RESONANT GENERATION CIRCUIT) **1116** generate resonance when alternating current power is applied thereto, and at this time, a vibration frequency may be determined based on an inductance of the transmitting (Tx) coil **1111b** and a capacitance of the resonant circuit (or RESONANT GENERATION CIRCUIT) **1116**. For this purpose, the inverter **1112** transforms a DC input obtained from the power supply unit **190** into an AC waveform, and the transformed AC current is applied to the transmitting (Tx) coil **1111b** and the resonant circuit (or RESONANT GENERATION CIRCUIT) **1116**.

In addition, the power conversion unit **111** may further include a frequency adjustment unit **1117** for changing a resonant frequency of the power conversion unit **111**. The resonant frequency of the power conversion unit **111** is determined based on an inductance and/or capacitance within a circuit constituting the power conversion unit **111** by Equation 1, and thus the power transmission control unit **112** may determine the resonant frequency of the power conversion unit **111** by controlling the frequency adjustment unit **1117** to change the inductance and/or capacitance.

The frequency adjustment unit **1117**, for example, may be configured to include a motor for adjusting a distance between capacitors included in the resonant circuit (or RESONANT GENERATION CIRCUIT) **1116** to change a capacitance, or include a motor for adjusting a number of turns or diameter of the transmitting (Tx) coil **1111b** to change an inductance, or include active elements for determining the capacitance and/or inductance.

On the other hand, the power conversion unit **111** may further include a power sensing unit **1115**. The operation of the power sensing unit **1115** is the same as the foregoing description.

Referring to FIG. 7B, a configuration of the power supply unit **290** included in the electronic device (or wireless power receiver) **200** will be described. The power supply unit **290**, as described above, may include the receiving (Rx) coil **2911b** and resonant circuit (or RESONANT GENERATION CIRCUIT) **2912**.

In addition, the power receiving unit **291** of the power supply unit **290** may further include a rectifier (or rectifying) circuit **2913** for converting an AC current generated by resonance phenomenon into DC. The rectifier (or rectifying) circuit **2913** may be configured similarly to the foregoing description.

Furthermore, the power receiving unit **291** may further include a power sensing unit **2914** for monitoring a voltage and/or current of the rectified power. The power sensing unit **2914** may be configured similarly to the foregoing description.

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FIG. 8—Wireless Power Transmitter Configured to Include One or More Transmitting Coils

FIG. 8 is a block diagram illustrating a wireless power transmitter configured to have one or more transmission coils receiving power according to an resonance coupling method that can be employed in the embodiments disclosed herein. Referring to FIG. 8, the power conversion unit **111** of the wireless power transmitter **100** according to the embodiments disclosed herein may include one or more transmitting coils **1111b-1** to **1111b-n** and resonant (or RESONANT GENERATION) circuits (**1116-1** to **1116-n**) connected to each transmitting coils. Furthermore, the power conversion unit **111** may further include a multiplexer **1113** for establishing and releasing the connection of some of the one or more transmitting coils **1111b-1** to **1111b-n**.

The one or more transmitting coils **1111b-1** to **1111b-n** may be configured to have the same vibration frequency, or some of them may be configured to have different vibration frequencies. It is determined by an inductance and/or capacitance of the resonant (or RESONANT GENERATION) circuits (**1116-1** to **1116-n**) connected to the one or more transmitting coils **1111b-1** to **1111b-n**, respectively.

In the meantime, when one or more electronic devices **200** are disposed in an active area or a detection area of the wireless power transmitter **100** including the one or more transmitting coils **1111b-1** to **1111b-n**, the power transmission control unit **112** may control the multiplexer **1113** to allow the electronic devices to be placed in different resonance coupling relations. Accordingly, the wireless power transmitter **100** may wirelessly transfer power to the one or more electronic devices by generating the wireless power signal using different coils.

In addition, the power transmission control unit **112** may set power with a different characteristic to be supplied to each of the coils corresponding to the electronic devices. Here, the wireless power transmitter **100** may transfer power by differently setting a power transmission scheme, a resonant frequency, efficiency, a characteristic and the like for each electronic device. The power transmission for one or more electronic devices will be described later with reference to FIG. 28. For this purpose, the frequency adjustment unit **1117** may be configured to change an inductance and/or capacitance of the resonant circuits (**1116-1** to **1116-n**) is connected to the one or more transmitting coils **1111b-1** to **1111b-n**, respectively.

FIG. 9—Wireless Power Transmitter Implemented by Charger

On the other hand, hereinafter, an example of the wireless power transmitter implemented in the form of a wireless charger will be described.

FIG. 9 is a block diagram illustrating a wireless power transmitter further including an additional element in addition to the configuration illustrated in FIG. 2A.

Referring to FIG. 9, the wireless power transmitter **100** may further include a sensor unit **120**, a communication unit **130**, an output unit **140**, a memory **150**, and a control unit (or Controller) **180** in addition to the power transmission unit **110** and power supply unit **190** for supporting at least one of the foregoing inductive coupling method and resonance coupling method.

The control unit (or Controller) **180** controls the power transmission unit **110**, the sensor unit **120**, the communication unit **130**, the output unit **140**, the memory **150**, and the power supply unit **190**.

The control unit (or Controller) **180** may be implemented by a module separated from the power transmission control

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unit **112** in the power transmission unit **110** described with reference to FIG. **2** or may be implemented by a single module.

The sensor unit **120** may include a sensor for detecting the location of the electronic device (or wireless power receiver) **200**. The location information detected by the sensor unit **120** may be used for allowing the power transmission unit **110** to transfer power in an efficient manner.

For instance, in case of wireless power transfer according to the inductive coupling method, the sensor unit **120** may be operated as a detection unit, and the location information detected by the sensor unit **120** may be used to move or rotate the is transmitting (Tx) coil **111a** in the power transmission unit **110**.

Furthermore, for example, the wireless power transmitter **100** configured to include the foregoing one or more transmitting coils may determine coils that can be placed in an inductive coupling relation or resonance coupling relation to the receiving coil of the electronic device (or wireless power receiver) **200** among the one or more transmitting coils based on the location information of the electronic device (or wireless power receiver) **200**.

On the other hand, the sensor unit **120** may be configured to monitor whether or not the electronic device (or wireless power receiver) **200** approaches a chargeable region. The approach or non-approach detection function of the sensor unit **120** may be carried out separately from the function of allowing the power transmission control unit **112** in the power transmission unit **110** to detect the approach or non-approach of the electronic device (or wireless power receiver) **200**. The communication unit **130** performs wired or wireless data communication with the electronic device (or wireless power receiver) **200**. The communication unit **130** may include an electronic component for at least any one of Bluetooth™, Zigbee, Ultra Wide Band (UWB), Wireless USB, Near Field Communication (NFC), and Wireless LAN.

The output unit **140** may include at least one of a display unit **141** and an audio output unit (or SOUND OUTPUT UNIT) **142**. The display unit **141** may include at least one of a liquid crystal display (LCD), a thin film transistor-liquid crystal display (TFT-LCD), an organic light-emitting diode (OLED), a flexible display, and a three-dimensional (3D) display. The display unit **141** may display a charging state under the control of the control unit (or Controller) **180**.

The memory **150** may include at least one storage medium of a flash memory type, a hard disk type, a multimedia card micro type, a card type memory (e.g., SD or XD memory), a random access memory (RAM), a static random access memory (SRAM), a read-only memory (ROM), an electrically erasable programmable read-only memory (EEPROM), a programmable read-only memory (PROM), a magnetic memory, a magnetic disk, an optical disk, and the like. The wireless power transmitter **100** may operate in association with a web storage performing the storage function of the memory **150** on the Internet. A program or commands performing the foregoing functions of the wireless power transmitter **100** may be stored in the memory **150**. The control unit (or Controller) **180** may perform the program or commands stored in the memory **150** to transmit power in a wireless manner. A memory controller (not shown) may be used to allow other constituent elements (e.g., control unit (or Controller) **180**) included in the wireless power transmitter **100** to access the memory **150**.

However, it would be easily understood by those skilled in the art that the configuration of a wireless power transmitter according to the embodiment disclosed herein may be applicable to an apparatus, such as a docking station, a terminal

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cradle device, and an electronic device, and the like, excluding a case where it is applicable to only a wireless charger.

FIG. **10**—Wireless Power Receiver Implemented with Mobile Terminal

FIG. **10** is view illustrating a configuration in case where an electronic device (or wireless power receiver) **200** according to the embodiments disclosed herein is implemented in the form of a mobile terminal.

The mobile communication terminal **200** may include a power supply unit **290** illustrated in FIG. **2**, **4**, or **7**.

Furthermore, the terminal **200** may further include a wireless communication unit **210**, an Audio/Video (A/V) input unit **220**, a user input unit **230**, a sensing unit **240**, an output unit **250**, a memory **260**, an interface unit **270**, and a controller **280**. FIG. **10** illustrates the terminal **100** having various components, but it is understood that implementing all of the illustrated components is not a requirement. Greater or fewer components may alternatively be implemented.

Hereinafter, each component is described in sequence.

The wireless communication unit **210** may typically include one or more modules which permit wireless communications between the terminal **200** and a wireless communication system or between the terminal **200** and a network within which the terminal **200** is located. For example, the wireless communication unit **210** may include a broadcast receiving module **211**, a mobile communication module **212**, a wireless internet module **213**, a short-range communication module **214**, a position location module **215** and the like.

The broadcast receiving module **211** receives a broadcast signal and/or broadcast associated information from an external broadcast managing entity via a broadcast channel.

The broadcast channel may include a satellite channel and a terrestrial channel.

The broadcast center may indicate a server which generates and transmits a broadcast signal and/or broadcast associated information or a server which receives a pre-generated broadcast signal and/or broadcast associated information and sends them to the portable terminal. The broadcast signal may be implemented as a TV broadcast signal, a radio broadcast signal, and a data broadcast signal, among others. The broadcast signal may further include a data broadcast signal combined with a TV or radio broadcast signal.

Examples of broadcast associated information may denote information associated with a broadcast channel, a broadcast program, a broadcast service provider, and the like. The broadcast associated information may be provided via a mobile communication network. In this case, it may be received by the mobile communication module **212**.

The broadcast associated information may be implemented in various formats. For instance, broadcast associated information may include Electronic Program Guide (EPG) of Digital Multimedia Broadcasting (DMB), Electronic Service Guide (ESG) of Digital Video Broadcast-Handheld (DVB-H), and the like.

The broadcast receiving module **211** may be configured to receive digital broadcast signals transmitted from various types of broadcast systems. Such broadcast systems may include Digital Multimedia Broadcasting-Terrestrial (DMB-T), Digital Multimedia Broadcasting-Satellite (DMB-S), Media Forward Link Only (MediaFLO), Digital Video Broadcast-Handheld (DVB-H), Integrated Services Digital Broadcast-Terrestrial (ISDB-T) and the like. The broadcast receiving module **211** may be configured to be suitable for every broadcast system transmitting broadcast signals as well as the digital broadcasting systems.

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Broadcast signals and/or broadcast associated information received via the broadcast receiving module **211** may be stored in a suitable device, such as a memory **260**.

The mobile communication module **212** transmits/receives wireless signals to/from at least any one of a base station, an external portable terminal, and a server on a mobile communication network. The wireless signal may include audio call signal, video (telephony) call signal, or various formats of data according to transmission/reception of text/multimedia messages.

The wireless internet module **213** supports wireless Internet access for the mobile terminal **200**. This module may be internally or externally coupled to the terminal **100**. Examples of such wireless Internet access may include Wireless LAN (WLAN) (Wi-Fi), Wireless Broadband (Wibro), Worldwide Interoperability for Microwave Access (Wimax), High Speed Downlink Packet Access (HSDPA) and the like.

The short-range communication module **214** denotes a module for short-range communications. Suitable technologies for implementing this module may include Bluetooth, Radio Frequency IDentification (RFID), Infrared Data Association (IrDA), Ultra-WideBand (UWB), ZigBee, and the like. On the other hand, Universal Serial Bus (USB), IEEE 1394, Thunderbolt of Intel technology, and the like, may be used for wired short-range communication.

The wireless internet module **213** or the short-range communication module **214** may establish data communication connection to the wireless power transmitter **100**.

Through the established data communication, when there is an audio signal to be outputted while transferring power in a wireless manner, the wireless internet module **213** or the short-range communication module **214** may transmit the audio signal to the wireless power transmitter **100** through the short-range communication module. Furthermore, through the established data communication, when there is information to be displayed, the wireless internet module **213** or the short-range communication module **214** may transmit the information to the wireless power transmitter **100**. Otherwise, the wireless internet module **213** or the short-range communication module **214** may transmit an audio signal received through a microphone integrated in the wireless power transmitter **100**. Furthermore, the wireless internet module **213** or the short-range communication module **214** may transmit the identification information (e.g., phone number or device name in case of a portable phone) of the mobile terminal **200** to the wireless power transmitter **100** through the established data communication.

The position location module **215** is a module for acquiring a position of the terminal. An example of the position location module **215** may include a Global Position System (GPS) module.

Referring to FIG. **10**, the A/V input unit **220** is configured to provide audio or video signal input to the portable terminal. The A/V input unit **220** may include a camera **221** and a microphone **222**. The camera **221** processes image frames of still or moving images obtained by an image sensor in a video call mode or a capture mode. The processed image frames may be displayed on the display unit **251**.

The image frames processed by the camera **221** may be stored in the memory **260** or transmitted to the exterior via the wireless communication unit **210**. Two or more cameras **221** may be provided therein according to the use environment.

The microphone **222** may receive an external audio signal by a microphone in a phone call mode, a recording mode, a voice recognition mode, or the like to process it into electrical audio data. The processed audio data is converted and outputted into a format transmittable to a mobile communication

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base station via the mobile communication module **212** in case of the phone call mode. The microphone **222** may include various noise removal algorithms to remove noises generated while receiving the external audio signal.

The user input unit **230** may generate input data to allow the user to control the operation of the terminal. The user input unit **230** may include a keypad, a dome switch, a touchpad (e.g., static pressure/capacitance), a jog wheel, a jog switch and the like.

The sensing unit **240** may include a proximity sensor **241**, a pressure sensor **242**, a motion sensor **243**, and the like. The proximity sensor **241** detects an object approaching the mobile terminal **200**, or the presence or absence of an object existing adjacent to the mobile terminal **200**, and the like without any mechanical contact. The proximity sensor **241** may detect a proximity object using a change of the AC magnetic field or static magnetic field, a change rate of the electrostatic capacity, or the like. Two or more proximity sensors **241** may be provided according to the aspect of configuration.

The pressure sensor **242** may detect whether or not a pressure is applied to the mobile terminal **200**, a size of the pressure, and the like. The pressure sensor **242** may be provided at a portion where the detection of a pressure is required in the mobile terminal **200** according to the use environment. When the pressure sensor **242** is provided in the display unit **251**, it may be possible to identify a touch input through the display unit **251** and a pressure touch input by which a pressure larger than the touch input is applied according to a signal outputted from the pressure sensor **242**. Furthermore, it may be possible to know a size of the pressure applied to the display unit **251** during the input of a pressure touch.

The motion sensor **243** detects the location or movement of the mobile terminal **200** using an acceleration sensor, a gyro sensor, and the like. The acceleration sensor used in the motion sensor **243** is an element for converting an acceleration change in any one direction into an electrical signal. Two or three axes are typically integrated into a package to constitute an acceleration sensor, and only one Z-axis may be required according to the use environment. Accordingly, when an acceleration sensor in the direction of X-axis or Y-axis should be used instead of the direction of Z-axis due to any reason, the acceleration sensor may be erected and mounted on a main substrate using a separate piece substrate. Furthermore, the gyro sensor is a sensor for measuring an angular speed of the mobile terminal **200** in a rotational movement to detect a rotated angle with respect to each reference direction. For instance, the gyro sensor may detect each rotational angle, i.e., azimuth, pitch and roll, with reference to three directional axes.

The output unit **250** is provided to output visual, auditory, or tactile information. The output unit **250** may include a display unit **251**, an audio output module **252**, an alarm unit **253**, a haptic module **254**, and the like.

The display unit **251** may display (output) information processed in the terminal **200**. For example, when the terminal is in a phone call mode, the display unit **251** will provide a User Interface (UI) or Graphic User Interface (GUI) associated with the call. When the terminal is in a video call mode or a capture mode, the display unit **251** may display images captured and/or received, UI, or GUI.

The display unit **251** may include at least one of a liquid crystal display (LCD), a thin film transistor-liquid crystal display (TFT-LCD), an organic light-emitting diode (OLED), a flexible display, a three-dimensional (3D) display, and the like.

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Some of those displays may be configured as a transparent type or an light transmission type through which the outside is visible, which is referred to as a transparent display. A representative example of the transparent display may include a Transparent OLED (TOLED), or the like. The rear surface of the display unit **151** may also be implemented to be optically transparent. Under this configuration, the user can view an object positioned at a rear side of the terminal body through a region occupied by the display unit **251** of the terminal body.

The display unit **251** may be implemented in two or more in number according to a configured aspect of the terminal **200**. For instance, a plurality of the display units **251** may be arranged on one surface to be spaced apart from or integrated with each other, or may be arranged on different surfaces.

Here, if the display unit **251** and a touch sensitive sensor (referred to as a touch sensor) have a layered structure therebetween, the display unit **251** may be used as an input device rather than an output device. The touch sensor may be implemented as a touch film, a touch sheet, a touch pad, and the like.

The touch sensor may be configured to convert changes of a pressure applied to a specific part of the display unit **251**, or a capacitance occurring from a specific part of the display unit **251**, into electric input signals. Also, the touch sensor may be configured to sense not only a touched position and a touched area, but also a touch pressure.

When touch inputs are sensed by the touch sensors, corresponding signals are sent to a touch controller. The touch controller processes the received signals, and then transmits corresponding data to the controller **280**. Accordingly, the controller **280** may sense which region of the display unit **151** has been touched.

The proximity sensor **241** may be arranged at an inner region of the terminal covered by the touch screen, or near the touch screen. The proximity sensor refers to a sensor to sense the presence or absence of an object approaching a surface to be sensed, or an object disposed near a surface to be sensed, using an electromagnetic field or infrared rays without a mechanical contact. The proximity sensor has a longer lifespan and a more enhanced utility than a contact sensor. The proximity sensor may include a transmissive type photoelectric sensor, a direct reflective type photoelectric sensor, a mirror reflective type photoelectric sensor, a high-frequency oscillation proximity sensor, a capacitance type proximity sensor, a magnetic type proximity sensor, an infrared rays proximity sensor, and so on. When the touch screen is implemented as a capacitance type, proximity of a pointer to the touch screen is sensed by changes of an electromagnetic field. In this case, the touch screen (touch sensor) may be categorized into a proximity sensor.

Hereinafter, for the sake of brief explanation, a status that the pointer is positioned to be proximate onto the touch screen without contact will be referred to as a "proximity touch", whereas a status that the pointer substantially comes in contact with the touch screen will be referred to as a "contact touch". For the position corresponding to the proximity touch of the pointer on the touch screen, such position corresponds to a position where the pointer faces perpendicular to the touch screen upon the proximity touch of the pointer.

The proximity sensor senses proximity touch, and proximity touch patterns (e.g., distance, direction, speed, time, position, moving status, etc.). Information relating to the sensed proximity touch and the sensed proximity touch patterns may be output onto the touch screen.

The audio output module **252** may output audio data received from the wireless communication unit **210** or stored in the memory **260**, in a call-receiving mode, a call-placing

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mode, a recording mode, a voice recognition mode, a broadcast reception mode, and so on. The audio output module **252** may output audio signals relating to functions performed in the terminal **200**, e.g., sound alarming a call received or a message received, and so on. The audio output module **252** may include a receiver, a speaker, a buzzer, and so on.

The alarm **253** outputs signals notifying the occurrence of an event from the terminal **200**. The event occurring from the terminal **100** may include call received, message received, key signal input, touch input, and so on. The alarm **253** may output not only video or audio signals, but also other types of signals such as signals notifying occurrence of events in a vibration manner. Since the video or audio signals can be output through the display unit **251** or the audio output unit **252**, the display unit **251** and the audio output module **252** may be categorized into part of the alarm **253**.

The haptic module **254** generates various tactile effects which a user can feel. A representative example of the tactile effects generated by the haptic module **254** includes vibration. Vibration generated by the haptic module **254** may have a controllable intensity, a controllable pattern, and so on. For instance, different vibration may be output in a synthesized manner or in a sequential manner.

The haptic module **254** may generate various tactile effects, including not only vibration, but also arrangement of pins vertically moving with respect to a skin being contacted, air injection force or air suction force through an injection hole or a suction hole, touch by a skin surface, presence or absence of contact with an electrode, effects by stimulus such as an electrostatic force, reproduction of cold or hot feeling using a heat absorbing device or a heat emitting device, and the like. The haptic module **254** may be configured to transmit tactile effects through the user's direct contact, or the user's muscular sense using a finger or a hand. The haptic module **254** may be implemented in two or more in number according to the configuration of the terminal **200**.

The memory **260** may store a program for the processing and control of the controller **280**. Alternatively, the memory **260** may temporarily store input/output data (e.g., phonebook data, messages, still images, video and the like). Also, the memory **260** may store data related to various patterns of vibrations and audio output upon the touch input on the touch screen.

In some embodiments, software components including an operating system (not shown), a module performing a wireless communication unit **210** function, a module operating together with the user input unit **230**, a module operating together with the A/V input unit **220**, a module operating together with the output unit **250** may be stored in the memory **260**. The operating system (e.g., LINUX, UNIX, OS X, WINDOWS, Chrome, Symbian, iOS, Android, VxWorks, or other embedded operating systems) may include various software components and/or drivers to control system tasks such as memory management, power management, and the like.

In addition, the memory **260** may store a setup program associated with contactless power transfer or wireless charging. The setup program may be implemented by the controller **280**.

Furthermore, the memory **260** may store an application associated with contactless power transfer (or wireless charging) downloaded from an application providing server (for example, an app store). The wireless charging related application is a program for controlling wireless charging transmission, and thus the electronic device (or wireless power receiver) **200** may receive power from the wireless power transmitter **100** in a wireless manner or establish connection

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for data communication with the wireless power transmitter **100** through the relevant program.

The memory **260** may be implemented using any type of suitable storage medium including a flash memory type, a hard disk type, a multimedia card micro type, a memory card type (e.g., SD or xD memory), a random access memory (RAM), a static random access memory (SRAM), a read-only memory (ROM), an electrically erasable programmable read-only memory (EEPROM), a programmable read-only memory (PROM), a magnetic memory, a magnetic disk, an optical disk, and the like. Also, the terminal **200** may be operated in association with a web storage performing the storage function of the memory **160** on the Internet.

The interface unit **270** may generally be implemented to interface the portable terminal with all external devices. The interface unit **270** may allow a data reception from an external device, a power delivery to each component in the terminal **200**, or a data transmission from the terminal **200** to an external device. The interface unit **270** may include, for example, wired/wireless headset ports, external charger ports, wired/wireless data ports, memory card ports, ports for coupling devices having an identification module, audio input/output (I/O) ports, video input/output (I/O) ports, earphone ports, and the like.

The identification module may be configured as a chip for storing various information required to authenticate an authority to use the terminal **200**, which may include a User Identity Module (UIM), a Subscriber Identity Module (SIM), and the like. Also, the device having the identification module (hereinafter, referred to as "identification device") may be implemented in a type of smart card. Hence, the identification device can be coupled to the terminal **200** via a port.

Also, the interface unit may serve as a path for power to be supplied from an external cradle to the terminal **200** when the terminal **100** is connected to the external cradle or as a path for transferring various command signals inputted from the cradle by a user to the terminal **200**. Such various command signals or power inputted from the cradle may operate as signals for recognizing that the terminal **200** has accurately been mounted to the cradle.

The controller **280** typically controls the overall operations of the terminal **200**. For example, the controller **280** performs the control and processing associated with telephony calls, data communications, video calls, and the like. The controller **280** may include a multimedia module **281** for multimedia playback. The multimedia module **281** may be implemented within the controller **280**, or implemented separately from the controller **280**.

The controller **280** can perform a pattern recognition processing so as to recognize a writing input or image drawing input carried out on the touch screen as a text or image.

The controller **280** performs wired or wireless charging according to the user input or internal input. Here, the internal input represents a signal for notifying that an induced current generated from a secondary coil within the terminal has been detected.

When the foregoing wireless charging is carried out, an operation of allowing the controller **280** to control each constituent element will be described in detail below with reference to the operation phase in FIG. **14**. As described above, the Power reception control unit (or POWER RECEIVING CONTROL UNIT) **292** within the power supply unit **290** may be implemented to be included in the controller **280**, and in the present disclosure, it should be understood that the controller **280** performs the operation by the Power reception control unit (or POWER RECEIVING CONTROL UNIT) **292**.

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The power supply unit **290** receives internal and external power under the control of the controller **280** to supply power required for the operation of each constituent element.

The power supply unit **290** is provided with a battery **299** for supplying power to each constituent element of the terminal **200**, and the battery **299** may include a charger (or charging unit) **298** for performing wired or wireless charging.

The present disclosure discloses a mobile terminal as an example of the apparatus for receiving power in a wireless manner, but it would be easily understood by those skilled in the art that the configuration according to the embodiment disclosed herein may be applicable to a stationary terminal, such as a digital TV, a desktop computer, and the like, excluding a case where it is applicable to only the mobile terminal.

FIGS. **11A** and **11B**—Backscatter Modulation

FIGS. **11A** and **11B** is a view illustrating the concept of transmitting and receiving a packet between a wireless power transmitter and an electronic device through the modulation and demodulation of a wireless power signal in transferring power in a wireless manner disclosed herein.

Referring to FIG. **11A**, the wireless power signal formed by the power conversion unit **111** forms a closed-loop within a magnetic field or electromagnetic field, and therefore, when the electronic device (or wireless power receiver) **200** modulates the wireless power signal while receiving the wireless power signal, the wireless power transmitter **100** may detect the modulated wireless power signal. The power communications modulation/demodulation unit **113** may demodulate the detected wireless power signal, and decodes the packet from the modulated wireless power signal.

On the other hand, a modulation method used for communication between the wireless power transmitter **100** and the electronic device (or wireless power receiver) **200** may be amplitude modulation. As described above, the amplitude modulation method may be a backscatter modulation method in which the power communications modulation/demodulation unit **293** at the side of the electronic device (or wireless power receiver) **200** changes an amplitude of the wireless power signal **10a** formed by the power conversion unit **111** and the Power reception control unit (or POWER RECEIVING CONTROL UNIT) **292** at the side of the wireless power transmitter **100** detects an amplitude of the modulated wireless power signal **10b**.

Specifically, further referring to FIG. **11B**, the Power reception control unit (or POWER RECEIVING CONTROL UNIT) **292** at the side of the electronic device (or wireless power receiver) **200** modulates the wireless power signal **10a** received through the power receiving unit **291** by changing a load impedance within the power communications modulation/demodulation unit **293**. The Power reception control unit (or POWER RECEIVING CONTROL UNIT) **292** modulates the wireless power signal **10a** to include a packet including a power control message to be transmitted to the wireless power transmitter **100**.

Then, the power transmission control unit **112** at the side of the wireless power transmitter **100** demodulates the modulated wireless power signal **10b** through an envelope detection process, and decodes the detected signal **10c** into digital data **10d**. The demodulation process detects a current or voltage flowing into the power conversion unit **111** to be classified into two states, a HI phase and a LO phase, and acquires a packet to be transmitted by the electronic device (or wireless power receiver) **200** based on digital data classified according to the states.

Hereinafter, a process of allowing the wireless power transmitter **100** to acquire a power control message to be transmit-

ted by the electronic device (or wireless power receiver) **200** from the demodulated digital data will be described.

FIGS. **12A** and **12B**—Bit Encoding, Byte Format

FIGS. **12A** and **12B** is a view illustrating a method of showing data bits and byte constituting a power control message provided by the wireless power transmitter **100**.

Referring to FIG. **12A**, the power transmission control unit **112** detects an encoded bit using a clock signal (CLK) from an envelope detected signal. The detected encoded bit is encoded according to a bit encoding method used in the modulation process at the side of the electronic device (or wireless power receiver) **200**. The bit encoding method may correspond to any one of non-return to zero (NRZ) and bi-phase encoding.

For instance, the detected bit may be a differential bi-phase (DBP) encoded bit. According to the DBP encoding, the Power reception control unit (or POWER RECEIVING CONTROL UNIT) **292** at the side of the electronic device (or wireless power receiver) **200** is allowed to have two state transitions to encode data bit **1**, and to have one state transition to encode data bit **0**. In other words, data bit **1** may be encoded in such a manner that a transition between the HI state and LO state is generated at a rising edge and falling edge of the clock signal, and data bit **0** may be encoded in such a manner that a transition between the HI state and LO state is generated at a rising edge of the clock signal.

On the other hand, the power transmission control unit **112** may acquire data in a byte unit using a byte format constituting a packet from a bit string detected according to the bit encoding method. For instance, the detected bit string may be transferred by using a 11-bit asynchronous serial format as illustrated in FIG. **12B**. In other words, the detected bit may include a start bit indicating the beginning of a byte and a stop bit indicating the end of a byte, and also include data bits (b0 to b7) between the start bit and the stop bit. Furthermore, it may further include a parity bit for checking an error of data. The data in a byte unit constitutes a packet including a power control message.

FIG. **13**—Packet Format

FIG. **13** is a view illustrating a packet including a power control message used in a contactless power transfer method according to the embodiments disclosed herein. The packet **500** may include a preamble **510**, a header **520**, a message **530**, and a checksum **540**.

The preamble **510** may be used to perform synchronization with data received by the wireless power transmitter **100** and detect the start bit of the header **520**. The preamble **510** may be configured to repeat the same bit. For instance, the preamble **510** may be configured such that data bit **1** according to the DBP encoding is repeated eleven to twenty five times.

The header **520** may be used to indicate a type of the packet **500**. A size of the message **530** and the kind thereof may be determined based on a value indicated by the header **520**. The header **520** is a value having a predetermined size to be positioned subsequent to the preamble **510**. For instance, the header **520** may be a byte in size.

The message **530** may be configured to include data determined based on the header **520**. The message **530** has a predetermined size according to the kind thereof.

The checksum **540** may be used to detect an error that can be occurred in the header **520** and the message **530** while transmitting a power control message. The header **520** and the message **530** excluding the preamble **510** for synchronization and the checksum **540** for error checking may be referred to as command-packet.

FIG. **14**—Operation Phases

Hereinafter, description will be given of operation phases of the wireless power transmitter **100** and the electronic device (or wireless power receiver) **200**.

FIG. **14** illustrates the operation phases of the wireless power transmitter **100** and electronic device (or wireless power receiver) **200** according to the embodiments disclosed herein. Furthermore, FIGS. **15** through **20** illustrates the structure of packets including a power control message between the wireless power transmitter **100** and electronic device (or wireless power receiver) **200**.

Referring to FIG. **14**, the operation phases of the wireless power transmitter **100** and the electronic device (or wireless power receiver) **200** for wireless power transfer may be divided into a selection phase (or state) **610**, a ping phase (or state) **620**, an identification and configuration phase (or state) **630**, and a power transfer phase (or state) **640**.

The wireless power transmitter **100** detects whether or not objects exist within a range that the wireless power transmitter **100** can transmit power in a wireless manner in the selection state **610**, and the wireless power transmitter **100** sends a detection signal to the detected object and the electronic device (or wireless power receiver) **200** sends a response to the detection signal in the ping state **620**. Furthermore, the wireless power transmitter **100** identifies the electronic device (or wireless power receiver) **200** selected through the previous states and acquires configuration information for power transmission in the identification and configuration state **630**. The wireless power transmitter **100** transmits power to the electronic device (or wireless power receiver) **200** while controlling power transmitted in response to a control message received from the electronic device (or wireless power receiver) **200** in the power transfer state **640**.

Hereinafter, each of the operation phases will be described in detail.

1) Selection State

The wireless power transmitter **100** in the selection state **610** performs a detection process to select the electronic device (or wireless power receiver) **200** existing within a detection area. The detection area, as described above, refers to a region in which an object within the relevant area can affect on the characteristic of the power of the power conversion unit **111**. Compared to the ping state **620**, the detection process for selecting the electronic device (or wireless power receiver) **200** in the selection state **610** is a process of detecting a change of the power amount for forming a wireless power signal in the power conversion unit at the side of the wireless power transmitter **100** to check whether any object exists within a predetermined range, instead of the scheme of receiving a response from the electronic device (or wireless power receiver) **200** using a power control message. The detection process in the selection state **610** may be referred to as an analog ping process in the aspect of detecting an object using a wireless power signal without using a packet in a digital format in the ping state **620** which will be described later.

The wireless power transmitter **100** in the selection state **610** can detect that an object comes in or out within the detection area. Furthermore, the wireless power transmitter **100** can distinguish the electronic device (or wireless power receiver) **200** capable of transferring power in a wireless manner from other objects (for example, a key, a coin, etc.) among objects located within the detection area.

As described above, a distance that can transmit power in a wireless manner may be different according to the inductive coupling method and resonance coupling method, and thus the detection area for detecting an object in the selection state **610** may be different from one another.

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First, in case where power is transmitted according to the inductive coupling method, the wireless power transmitter **100** in the selection state **610** can monitor an interface surface (not shown) to detect the alignment and removal of objects. Furthermore, the wireless power transmitter **100** may detect the location of the electronic device (or wireless power receiver) **200** placed on an upper portion of the interface surface. As described above, the wireless power transmitter **100** formed to include one or more transmitting coils may perform the process of entering the ping state **620** in the selection state **610**, and checking whether or not a response to the detection signal is transmitted from the object using each coil in the ping state **620** or subsequently entering the identification state **630** to check whether identification information is transmitted from the object. The wireless power transmitter **100** may determine a coil to be used for contactless power transfer based on the detected location of the electronic device (or wireless power receiver) **200** acquired through the foregoing process.

Furthermore, when power is transmitted according to the resonance coupling method, the wireless power transmitter **100** in the selection state **610** can detect an object by detecting that any one of a frequency, a current and a voltage of the power conversion unit is changed due to an object located within the detection area.

On the other hand, the wireless power transmitter **100** in the selection state **610** may detect an object by at least any one of the detection methods using the inductive coupling method and resonance coupling method. The wireless power transmitter **100** may perform an object detection process according to each power transmission method, and subsequently select a method of detecting the object from the coupling methods for contactless power transfer to advance to other states **620**, **630**, **640**.

On the other hand, for the wireless power transmitter **100**, a wireless power signal formed to detect an object in the selection state **610** and a wireless power signal formed to perform digital detection, identification, configuration and power transmission in the subsequent states **620**, **630**, **640** may have a different characteristic in the frequency, strength, and the like. It is because the selection state **610** of the wireless power transmitter **100** corresponds to an idle state for detecting an object, thereby allowing the wireless power transmitter **100** to reduce consumption power in the idle state or generate a specialized signal for effectively detecting an object.

## 2) Ping State

The wireless power transmitter **100** in the ping state **620** performs a process of detecting the electronic device (or wireless power receiver) **200** existing within the detection area through a power control message. Compared to the detection process of the electronic device (or wireless power receiver) **200** using a characteristic of the wireless power signal and the like in the selection state **610**, the detection process in the ping state **620** may be referred to as a digital ping process.

The wireless power transmitter **100** in the ping state **620** forms a wireless power signal to detect the electronic device (or wireless power receiver) **200**, modulates the wireless power signal modulated by the electronic device (or wireless power receiver) **200**, and acquires a power control message in a digital data format corresponding to a response to the detection signal from the modulated wireless power signal. The wireless power transmitter **100** may receive a power control message corresponding to the response to the detection signal to recognize the electronic device (or wireless power receiver) **200** which is a subject of power transmission.

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The detection signal formed to allowing the wireless power transmitter **100** in the ping state **620** to perform a digital detection process may be a wireless power signal formed by applying a power signal at a specific operating point for a predetermined period of time. The operating point may denote a frequency, duty cycle, and amplitude of the voltage applied to the transmitting (Tx) coil. The wireless power transmitter **100** may generate the detection signal generated by applying the power signal at a specific operating point for a predetermined period of time, and attempt to receive a power control message from the electronic device (or wireless power receiver) **200**.

On the other hand, the power control message corresponding to a response to the detection signal may be a message indicating a strength of the wireless power signal received by the electronic device (or wireless power receiver) **200**. For example, the electronic device (or wireless power receiver) **200** may transmit a signal strength packet **5100** including a message indicating the received strength of the wireless power signal as a response to the detection signal as illustrated in FIG. **15**. The packet **5100** may include a header **5120** for notifying a packet indicating the signal strength and a message **5130** indicating a strength of the power signal received by the electronic device (or wireless power receiver) **200**. The strength of the power signal within the message **5130** may be a value indicating a degree of inductive coupling or resonance coupling for power transmission between the wireless power transmitter **100** and the electronic device (or wireless power receiver) **200**.

The wireless power transmitter **100** may receive a response message to the detection signal to find the electronic device (or wireless power receiver) **200**, and then extend the digital detection process to enter the identification and configuration state **630**. In other words, the wireless power transmitter **100** maintains the power signal at a specific operating point subsequent to finding the electronic device (or wireless power receiver) **200** to receive a power control message required in the identification and configuration state **630**.

However, if the wireless power transmitter **100** is not able to find the electronic device (or wireless power receiver) **200** to which power can be transferred, then the operation phase of the wireless power transmitter **100** will be returned to the selection state **610**.

## 3) Identification and Configuration State

The wireless power transmitter **100** in the identification and configuration state **630** may receive identification information and/or configuration information transmitted by the electronic device (or wireless power receiver) **200**, thereby controlling power transmission to be effectively carried out.

The electronic device (or wireless power receiver) **200** in the identification and configuration state **630** may transmit a power control message including its own identification information. For this purpose, the electronic device (or wireless power receiver) **200**, for instance, may transmit an identification packet **5200** including a message indicating the identification information of the electronic device (or wireless power receiver) **200** as illustrated in FIG. **16A**. The packet **5200** may include a header **5220** for notifying a packet indicating identification information and a message **5230** including the identification information of the electronic device. The message **5230** may include information (**5231** and **5232**) indicating a version of the contract for contactless power transfer, information **5233** for identifying a manufacturer of the electronic device (or wireless power receiver) **200**, information **5234** indicating the presence or absence of an extended device identifier, and a basic device identifier **5235**. Furthermore, if it is displayed that an extended device iden-

tifier exists in the information **5234** indicating the presence or absence of an extended device identifier, then an extended identification packet **5300** including the extended device identifier as illustrated in FIG. 16B will be transmitted in a separate manner. The packet **5300** may include a header **5320** for notifying a packet indicating an extended device identifier and a message **5330** including the extended device identifier. When the extended device identifier is used as described above, information based on the manufacturer's identification information **5233**, the basic device identifier **5235** and the extended device identifier **5330** will be used to identify the electronic device (or wireless power receiver) **200**.

The electronic device (or wireless power receiver) **200** may transmit a power control message including information on expected maximum power in the identification and configuration state **630**. To this end, the electronic device (or wireless power receiver) **200**, for instance, may transmit a configuration packet **5400** as illustrated in FIG. 17. The packet may include a header **5420** for notifying that it is a configuration packet and a message **5430** including information on the expected maximum power. The message **5430** may include power class **5431**, information **5432** on expected maximum power, an indicator **5433** indicating a method of determining a current of a main cell at the side of the wireless power transmitter, and the number **5434** of optional configuration packets. The indicator **5433** may indicate whether or not a current of the main cell at the side of the wireless power transmitter is determined as specified in the contract for wireless power transfer.

Meanwhile, the electronic device (or wireless power receiver) **200** according to the exemplary embodiments may transmit a power control message, which includes required power information thereof and associated profile information, to the wireless power transmitter **100**. In some exemplary embodiments, the required power information related to the electronic device (or wireless power receiver) **200** or the profile information may be transmitted by being included in the configuration packet **5400** as illustrated in FIG. 17. Alternatively, the required power information related to the electronic device (or wireless power receiver) **200** or the profile information may be transmitted by being included in a separate packet for configuration.

On the other hand, the wireless power transmitter **100** may generate a power transfer contract which is used for power charging with the electronic device (or wireless power receiver) **200** based on the identification information and/or configuration information. The power transfer contract may include the limits of parameters determining a power transfer characteristic in the power transfer state **640**.

The wireless power transmitter **100** may terminate the identification and configuration state **630** and return to the selection state **610** prior to entering the power transfer state **640**. For instance, the wireless power transmitter **100** may terminate the identification and configuration state **630** to find another electronic device that can receive power in a wireless manner.

#### 4) Power Transfer State

The wireless power transmitter **100** in the power transfer state **640** transmits power to the electronic device (or wireless power receiver) **200**.

The wireless power transmitter **100** may receive a power control message from the electronic device (or wireless power receiver) **200** while transferring power, and control a characteristic of the power applied to the transmitting coil in response to the received power control message. For example, the power control message used to control a characteristic of the power applied to the transmitting coil may be included in

a control error packet **5500** as illustrated in FIG. 18. The packet **5500** may include a header **5520** for notifying that it is a control error packet and a message **5530** including a control error value. The wireless power transmitter **100** may control the power applied to the transmitting coil according to the control error value. In other words, a current applied to the transmitting coil may be controlled so as to be maintained if the control error value is "0", reduced if the control error value is a negative value, and increased if the control error value is a positive value.

The wireless power transmitter **100** may monitor parameters within a power transfer contract generated based on the identification information and/or configuration information in the power transfer state **640**. As a result of monitoring the parameters, if power transmission to the electronic device (or wireless power receiver) **200** violates the limits included in the power transfer contract, then the wireless power transmitter **100** may cancel the power transmission and return to the selection state **610**.

The wireless power transmitter **100** may terminate the power transfer state **640** based on a power control message transferred from the electronic device (or wireless power receiver) **200**.

For example, if the charging of a battery has been completed while charging the battery using power transferred by the electronic device (or wireless power receiver) **200**, then a power control message for requesting the suspension of wireless power transfer will be transferred to the wireless power transmitter **100**. In this case, the wireless power transmitter **100** may receive a message for requesting the suspension of the power transmission, and then terminate wireless power transfer, and return to the selection state **610**.

For another example, the electronic device (or wireless power receiver) **200** may transfer a power control message for requesting renegotiation or reconfiguration to update the previously generated power transfer contract. The electronic device (or wireless power receiver) **200** may transfer a message for requesting the renegotiation of the power transfer contract when it is required a larger or smaller amount of power than the currently transmitted power amount. In this case, the wireless power transmitter **100** may receive a message for requesting the renegotiation of the power transfer contract, and then terminate contactless power transfer, and return to the identification and configuration state **630**.

To this end, a message transmitted by the electronic device (or wireless power receiver) **200**, for instance, may be an end power transfer packet **5600** as illustrated in FIG. 19. The packet **5600** may include a header **5620** for notifying that it is an end power transfer packet and a message **5630** including an end power transfer code indicating the cause of the suspension. The end power transfer code may indicate any one of charge complete, internal fault, over temperature, over voltage, over current, battery failure, reconfigure, no response, and unknown error.

Hereinafter, the structure of a receiving coil according to an embodiment disclosed herein will be described in detail with reference to FIGS. 20 through 26.

In general, a contactless wireless charging method is an energy transfer method capable of transferring energy in an electromagnetic manner in which wires are removed from the method of transferring energy used as a power source of the electronic device through wires in the related art.

There may have been a magnetic induction method for the contactless wireless charging method.

The magnetic induction method may be a power transmission method using an electromagnetic induction method in which the power transmission unit (or power conversion unit)

111 generates a magnetic field through the power transmitting coil (primary coil) 1111 and positioning the receiving coil (secondary coil) 2911 at a position where current is inducted.

It has been put to practical use in a device frequently used in our real lives such as power toothbrush, wireless coffee pot, or the like, and recently years, has been commercialized even in charging a mobile device.

Wireless Power Consortium (hereinafter, abbreviated as "WPC") has standardized power transmission related technologies to allow wireless power transmitters and receivers manufactured by different companies to perform their roles in an efficient manner. For example, the standard may be System Description Wireless Power Transfer, Volume I: Low Power, Part 1: Interface Definition, Version 1.0 (released in July 2010) or Version 1.1 (released in March 2012).

Structure of Receiving Coil According to an Embodiment Disclosed Herein

A technology disclosed herein is an extension of small power (5 W) power transmission standard defined and released by the WPC and may relate to the structure of a receiving coil for middle power transfer with a capacity higher than the present.

The summary of a receiving coil disclosed herein will be described as follows.

1) A receiving coil may be configured using two or more coils as increasing the capacity of wireless power transmission.

2) Furthermore, a power receiving coil may be configured such that an individual wire of a bifilar wound coil is connected with a separate terminal. In this case, the number of receiving coils may not be increased.

According to the structure of a receiving coil disclosed herein, it may be possible to provide a solution for a heat dissipation issue generated during the large output wireless power transfer process.

Furthermore, high power may be transferred in a divided manner, thereby providing the function of dividing a heat dissipation source generated during the power transfer process.

Furthermore, it may be possible to obtain a slim design of the high power wireless power receiver.

Furthermore, the configuration of a middle power receiving circuit unit may be implemented to be dispersed with a low power design, and thus the technology disclosed herein may be applicable to a mobile device.

A wireless power receiver according to an embodiment disclosed herein may be a wireless power receiver configured to receive a wireless power signal from a wireless power transmitter to receive wireless power, and the wireless power receiver may include a receiving coil unit comprising a primary coil and a secondary coil receiving the wireless power signal, and a charger configured to charge power which is a sum of wireless power received by the primary coil and the secondary coil, respectively, based on the wireless power signal.

According to an embodiment, the primary coil may be a coil capable of receiving the wireless power signal as first rated power, and the secondary coil may be a coil capable of receiving the wireless power signal as second rated power.

Here, the first rated power and the second rated power may be 5 W.

Furthermore, according to an embodiment, the primary coil may be formed such that two wires connecting between the first terminal and the second terminal are wound in the form of a bifilar winding, and the secondary coil may be

formed such that two wires connecting between the third terminal and the fourth terminal are wound in the form of a bifilar winding.

Furthermore, according to an embodiment, the primary coil may be formed such that a first wire connecting between the first terminal and the second terminal is wound, and the secondary coil may be formed such that a second wire connecting between the third terminal and the fourth terminal is wound, and the first wire and the second wire may be wound together in the form of a bifilar winding.

Furthermore, according to an embodiment, the wireless power receiver may further include a rectifier unit configured to convert an alternating current signal generated by the primary coil and the secondary coil into a direct current signal based on the wireless power signal, wherein the charger charges power which is a sum of wireless power received by the primary coil and the secondary coil, respectively, based on the direct current signal.

Furthermore, according to an embodiment, the rectifier unit may include a first rectifier circuit configured to convert a first alternating current signal generated by the primary coil into a first direct current signal and a second rectifier circuit configured to convert a second alternating current signal generated by the secondary coil into a second direct current signal, and the charger may charge power which is a sum of wireless power received by the primary coil and the secondary coil, respectively, based on the first direct current signal and the second direct current signal.

FIG. 20 is a configuration view illustrating a wireless power receiver according to an embodiment disclosed herein.

Referring to FIG. 20, the wireless power receiver 100 according to an embodiment disclosed herein may include a receiving coil unit 2911 and a charger 298.

Furthermore, the wireless power receiver 100 may further include a rectifier unit (not shown).

Hereinafter, the constituent elements will be described in sequence.

The receiving coil unit 2911 may include a primary coil and a secondary coil receiving the wireless power signal from the wireless power transmitter.

The primary coil may be a coil capable of receiving the wireless power signal as first rated power, and the secondary coil may be a coil capable of receiving the wireless power signal as second rated power.

Here, the first rated power and the second rated power may be 5 W.

The meaning of "rated power" in the first rated power and the second rated power may be a term with a typical meaning used in the present technical field. For example, the "rated power" may denote a power value at which the coils (the primary coil and the secondary coil) can normally receive wireless power through the reception of the wireless power signal. In other words, it may denote a wireless power energy that can be received without causing an effect on the hardware characteristics of the coils.

Accordingly, the receiving coil unit 2911 can receive the wireless power with rated power which is a sum of the first rated power and the second rated power through the provision of the primary coil and the secondary coil (or operated with the summed rated power).

For example, when the first rated power and the second rated power are 5 W, the receiving coil unit 2911 may normally receive wireless power up to 10 W.

In this manner, there may be an advantage of achieving the design of a middle power rated receiving coil using small power rated coils.

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Moreover, in case of increasing the number of the small power rated coils, the receiving coil unit **2911** may be operated with a larger rated power energy.

The charger **298** may perform the role of charging power which is a sum of wireless power received by the primary coil and the secondary coil, respectively, based on the wireless power signal.

To this end, the output of the charger **298** may be connected to a battery to charge the summed power to the battery.

According to still another embodiment, the charger **298** may include a battery capable of charging power which is a sum of wireless power received by the primary coil and the secondary coil, respectively.

The rectifier unit may perform the role of converting an alternating current signal (for example, alternating current) generated by the primary coil and the secondary coil into a direct current signal (for example, direct current).

In this case, the charger **298** may charge power which is a sum of wireless power received by the primary coil and the secondary coil, respectively, based on the direct current signal.

Specifically, the rectifier unit may include a first rectifier circuit configured to convert a first alternating current signal generated by the primary coil into a first direct current signal and a second rectifier circuit configured to convert a second alternating current signal generated by the secondary coil into a second direct current signal.

Accordingly, the charger **298** may charge power which is a sum of wireless power received by the primary coil and the secondary coil, respectively, based on the first direct current signal and the second direct current signal.

For example, the charger **298** may receive a direct current signal which is a sum of the first direct current signal and the second direct current signal, and charge power which is a sum of wireless power received by the primary coil and the secondary coil, respectively, based on the summed direct current signal.

FIG. **21** is an exemplary view illustrating a receiving coil unit according to an embodiment disclosed herein.

Referring to FIG. **21**, the receiving coil unit **2911** may include a primary coil **2911'** and a secondary coil **2911''**.

Furthermore, the receiving coil unit **2911** may further include a shielding portion (**SH110**) for preventing the received wireless power signal from being passed out in a specific direction.

The shielding portion (**SH110**) may be provided with a recessed structure accommodating the primary coil **2911'** and the secondary coil **2911''** (refer to FIG. **21**).

For example, the specific direction may be a direction passing through the shielding portion (**SH110**).

According to an embodiment, the primary coil **2911'** and the secondary coil **2911''** may be circular wound coils.

Furthermore, according to an embodiment, the primary coil **2911'** may receive the wireless power signal with first rated power (or may be operated with first rated power).

Furthermore, the secondary coil **2911''** may receive the wireless power signal with second rated power (or may be operated with second rated power).

For example, the first rated power may be 5 W, and the second rated power may be 15 W. In this case, the receiving coil unit **2911** may have rated power of total 20 W.

According to an embodiment, the primary coil **2911'** and the secondary coil **2911''** may be joined (or adhered) to each other such that their directions of receiving the wireless power signal are identical.

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For example, as illustrated in FIG. **21**, the primary coil **2911'** and the secondary coil **2911''** may be joined in the top/down direction to face each other.

An adhesive agent or the like may be used to join the primary coil **2911'** to the secondary coil **2911''**.

According to an embodiment, the primary coil **2911'** may be formed such that two wound in the two wires connecting between the first terminal (**t110**) and the second terminal (**t120**) are wound in the form of a bifilar winding.

Furthermore, the secondary coil is formed such that two wires connecting between the third terminal (**t210**) and the fourth terminal (**t220**) are wound in the form of a bifilar winding.

The bifilar shaped winding may have a generally known meaning in the present technical field.

In general, the bifilar shaped winding (or bifilar coil) may denote that two wires (or filaments, strands) are closely wound in parallel to each other (two closely spaced, parallel windings).

FIG. **22** is an exemplary view illustrating a bifilar winding according to an embodiment disclosed herein.

Referring to FIG. **22**, it is seen a shape wound in the form of a bifilar winding.

Referring to the upper drawing of FIG. **22**, there is disclosed a structure in which two wires (**L110**, **L120**) are wound in parallel around the first core (**C110**) and both ends thereof are combined with each other.

Furthermore, referring to the lower drawing of FIG. **22**, there is disclosed a structure in which two wires (**L210**, **L220**) are wound in parallel around the first core (**C110**) and both ends thereof are open to each other.

According to an embodiment, the primary coil **2911'** and the secondary coil **2911''** illustrated in FIG. **21** may be formed such that two wires connecting between two terminals (for example, the first terminal (**t110**) and the second terminal (**t120**) or the third terminal (**t210**) and the fourth terminal (**t220**)) are wound in the form of a bifilar winding as illustrated in the lower drawing of FIG. **22**.

FIG. **23** is another exemplary view illustrating a bifilar winding according to another embodiment disclosed herein.

Referring to FIG. **23**, it is seen a coil structure in which two wires (**L310**, **L320**) are wound in parallel in a circular shape.

It may be referred to as a circular shaped bifilar coil.

FIG. **24** is a view illustrating the structure or a receiving coil unit according to another embodiment disclosed herein.

Referring to FIG. **24**, the receiving coil unit **2911** may include a third coil **2911'''** and a shielding portion (**SH120**).

The third coil **2911'''** may have a structure in which the primary coil with first rated power and the secondary coil with second rated power are wound together in the form of a bifilar winding.

Specifically, according to still another embodiment disclosed herein, the third coil **2911'''** may include a primary coil formed such that a first wire connecting between the first terminal (**t110**) and the second terminal (**t120**) are wound in the form of a bifilar winding and a secondary coil formed such that a second wire connecting between the third terminal (**t210**) and the fourth terminal (**t220**) are wound in the form of a bifilar winding.

Here, the first wire and the second wire may be wound together in the form of a bifilar winding (refer to FIG. **24**).

Accordingly, the receiving coil unit disclosed in FIG. **24** may be configured such that two coils are located on the same plane, contrary to the receiving coil unit disclosed in FIG. **21**.

FIG. **25** is an exemplary view illustrating a wireless power receiver according to an embodiment disclosed herein.

Referring to FIG. 25, the wireless power receiver 200 according to an embodiment disclosed herein may include a primary coil 2911', a secondary coil 2911", a rectifier unit 2913, and a charger 298.

Furthermore, the wireless power receiver 200 may further include a combining unit (A110).

The primary coil 2911' may be formed such that two wires connecting between the first terminal (t110) and the second terminal (t120) are wound in the form of a bifilar winding.

Furthermore, the secondary coil 2911" may be formed such that two wires connecting between the third terminal (t210) and the fourth terminal (t220) are wound in the form of a bifilar winding.

The primary coil 2911' and the secondary coil 2911" may be joined to each other such that their directions for receiving the wireless power signal are identical.

For example, the primary coil 2911' and the secondary coil 2911" may be joined in the top/down direction to face each other.

The rectifier unit 2913 may perform the role of converting an alternating current signal generated by the primary coil and the secondary coil into a direct current signal based on the wireless power signal.

In case of FIG. 25, the rectifier unit 2913 may include a first rectifier unit 2913' configured to convert a first alternating current signal generated by the primary coil 2911' into a first direct current signal and a second rectifier circuit 2913" configured to convert a second alternating current signal generated by the secondary coil 2911" into a second direct current signal.

Specifically, the first rectifier unit 2913' receives the first alternating current signal through the first terminal (t110) and the second terminal (t120) to rectify the first alternating current signal into a first direct current signal.

Furthermore, the second rectifier unit 2913" receives the second alternating current signal through the third terminal (t210) and the fourth terminal (t220) to rectify the second alternating current signal into a second direct current signal.

The charger 298 may perform the role of charging power which is a sum of wireless power received by the primary coil 2911' and the secondary coil 2911", respectively, based on the direct current signal.

In case of FIG. 25, the charger 298 may charge power which is a sum of wireless power received by the primary coil 2911' and the secondary coil 2911", respectively, based on the first direct current signal and the second direct current signal.

The combining unit (A110) may perform the role of outputting a direct current signal which is a sum of the first direct current signal and the second direct current signal.

The direct current signal which is a sum of the first direct current signal and the second direct current signal may be transferred to the charger 298, and the charger 298 may charge power which is a sum of wireless power received by the primary coil 2911' and the secondary coil 2911", respectively, based on the summed direct current signal.

The combining unit (A110) may include a constituent element for summing the first direct current signal and the second direct current signal. For example, the combining unit (A110) may simply enable the first direct current signal and the second direct current signal to be wired-ORed to provide the summed direct current signal to the charger 298.

FIG. 26 is an exemplary view illustrating a wireless power receiver according to another embodiment disclosed herein.

Referring to FIG. 26, the wireless power receiver 200 according to still another embodiment disclosed herein may include a third coil 2911', a rectifier unit 2913, and a charger 298.

Furthermore, the wireless power receiver 200 may further include a combining unit (A110).

The third coil 2911'" may include a primary coil formed such that a first wire connecting between the first terminal (t110) and the second terminal (t120) is wound and a secondary coil formed such that a second wire connecting between the third terminal (t210) and the fourth terminal (t220) is wound.

Here, the first wire and the second wire may be wound together in the form of a bifilar winding.

Accordingly, the primary coil and secondary coil contained in the third coil 2911'" disclosed in FIG. 26 may be configured such that two coils are located on the same plane, contrary to the primary coil 2911' and secondary coil 2911" disclosed in FIG. 25.

Accordingly, the third coil 2911'" may have a slimmer design than a structure in which the primary coil 2911' and secondary coil 2911" are joined to each other.

The role of the rectifier unit 2913, the charger 298 and the combining unit (A110) is the same as described above, and thus their description thereof will be omitted.

Structure of Transmitting Coil According to an Embodiment Disclosed Herein

A single TX coil type proposed for small power (5 W class) which is defined and released by the Wireless Power Consortium (WPC) uses a magnet for Align Assistance (or Alignment Aid) of the TX/RX coil.

In other words, a wireless power transmission method used in this standard can transfer energy at the maximum efficiency when a magnetic flux between the transmitter and receiver should be shared at the maximum level, and thus a magnet may be used for posture adjustment.

The technology disclosed in the present disclosure relates to a structure of the transmitting coil aligned with the receiving coil regardless of (or without) a magnet to transmit wireless power for the improvement of foreign substance adhesion and magnetic field saturation effect.

Specifically, the technology disclosed in the present disclosure relates to a transmitting (Tx) coil assembly having a structure in which a magnet for align assistance is removed from the transmitting (Tx) coil assembly proposed by the existing WPC standard.

The structure of a transmitting coil disclosed herein may provide the following advantages.

1) Material cost reduction effect through magnet removal  
2) The thickness of a receiving unit shielding material can be reduced—As decreasing the thickness of a shield material of the receiver for the purpose of a mobile device, the charging efficiency and recognition problem should be considered when there is an alignment magnet (location adjustment magnet or combined auxiliary magnet).

3) Prevention of foreign substance adhesion to a board included in the transmitter and its resultant overpower leakage problem can be prevented.

4) Adverse effect on a coil induced magnetic field by a magnet generated magnetic field coil can be prevented.

The wireless power transmitter according to an embodiment disclosed herein may be a wireless power transmitter configured to generate a wireless power signal through a transmitting (Tx) coil assembly to transfer wireless power to the wireless power receiver.

Here, the transmitting (Tx) coil assembly may include a transmitting coil configured to generate the wireless power signal, and a shielding portion configured to shield transmission in a specific direction of the wireless power signal and provided with a recessed structure accommodating the trans-

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mitting coil, but may not include a magnet for alignment aid with the receiving coil of the wireless power receiver.

According to an embodiment, the transmitting coil may be aligned with the receiving coil regardless of a magnet for alignment aid with the receiving coil of the wireless power receiver.

Furthermore, according to an embodiment, the transmitting coil may be aligned with the receiving coil without a magnet for alignment aid (or Alignment Assistance) with the receiving coil of the wireless power receiver.

According to an embodiment, the specific direction may be a direction opposite to the direction in which the wireless power signal is transmitted to the receiving coil.

Furthermore, according to an embodiment, the wireless power transmitter may further include an auxiliary means for the alignment aid or Align Assistance.

The auxiliary means may be a means for locating the wireless power receiver in a valid region (aligned region) to align between the receiving coil and the transmitting coil.

Here, the auxiliary means may be at least one of a display module for displaying alignment information with the receiving coil, an audio output module, and a haptic module.

The display module may be an auxiliary means based on a visual feedback display (for example, LED lighting informing a suitable position).

The audio output module may be an auxiliary means based on a feedback mechanism through sound or haptic interaction.

Furthermore, according to an embodiment, the transmitting (Tx) coil assembly may further include an interface surface facing the receiving coil.

In this case, the auxiliary means may be a marker or lighting means provided on the interface surface for alignment aid with the receiving coil.

FIG. 27 is an exemplary view illustrating the structure of a transmitting (Tx) coil assembly according to an embodiment disclosed herein.

Referring to FIG. 27, in general, a wireless power transmitter may include a transmitting coil configured to generate the wireless power signal, and a shielding portion (SH210) configured to shield transmission in a specific direction of the wireless power signal and provided with a recessed structure accommodating the transmitting coil.

The shield material constituting the shielding portion (SH210) is as follows.

- 1) Material 44—Fair Rite Corporation.
- 2) Material 28—Steward, Inc.
- 3) CMG22G—Ceramic Magnetics, Inc.
- 4) Kolektor 22G—Kolektor.
- 5) LeaderTech SB28B2100-1—LeaderTech Inc.
- 6) TopFlux “A”—TopFlux.
- 7) TopFlux “B”—TopFlux.
- 8) ACME K081—Acme Electronics.
- 9) L7H—TDK Corporation.
- 10) PE22—TDK Corporation.
- 11) FK2—TDK Corporation

The shielding portion (SH210) may be formed of a composite material of the above shield materials.

Here, the specific direction may be a direction opposite to the direction in which the wireless power signal is transmitted to the receiving coil.

In case of FIG. 27, a transmitting (Tx) coil assembly (CA110) disclosed in the existing WPC standard may include a shielding portion (SH210') and a transmitting coil 1111' and a magnet (M110) for alignment aid or Align Assistance with the receiving coil of the wireless power receiver 200 accommodated in the shielding portion.

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A transmitting (Tx) coil assembly (CA210) according to an embodiment disclosed herein may be aligned with the receiving coil without the magnet (M110) or regardless of the magnet (M110), contrary to the existing transmitting (Tx) coil assembly (CA110).

FIG. 28 is an exemplary view illustrating the standard of a transmitting coil is according to an embodiment disclosed herein.

Referring to FIG. 28, the transmitting coil is a circular wound coil, and provided with an outer diameter (do) and an inner diameter (di).

Furthermore, the transmitting coil has a thickness of dc.

The detailed description of the transmitting coil is disclosed in the WPC standard.

FIG. 29 is an exemplary view illustrating the standard of a transmitting (Tx) coil assembly according to an embodiment disclosed herein.

Referring to FIG. 29, a transmitting (Tx) coil assembly according to an embodiment disclosed herein may include a shielding portion (refer to FIG. 29), a transmitting coil (primary coil in FIG. 29), and an interface surface.

The summary of the primary coil assembly of the power transmitter design is as follows.

1) The interface surface allows a slight curvature. Here, the

curvature radius may be minimum 317 mm.

2) A distance between the interface surface and the coil may be about 1.75-2.5 mm.

3) A clearance between the shield and the coil may be 1 mm.

The detailed description of the transmitting (Tx) coil assembly is disclosed in the WPC standard.

According to an embodiment, the wireless power transmitter 100 may further include an auxiliary means for alignment aid or Align Assistance with the receiving coil of the wireless power receiver 200.

Here, the auxiliary means may be at least one of a display module for displaying alignment information with the receiving coil, an audio output module, and a haptic module.

FIG. 30 is an exemplary view illustrating an auxiliary means for alignment aid or Align Assistance according to an embodiment disclosed herein.

Referring to FIG. 30, the auxiliary means for alignment aid or Align Assistance with the receiving coil may be a display module.

In case of FIG. 30, the display module may be LED lighting (SP110).

The LED lighting (SP110) may be located on a charging region (R110).

The charging region (R110) may be formed in various ways. For example, the charging region (R110) may be formed on a surface at which the transmitting coil of the wireless power transmitter 100 is located. Otherwise, for example, the charging region (R110) may be formed on a charging pad connected to the wireless power transmitter 100 in a wired or wireless manner.

According to an embodiment, the user of the wireless power receiver 200 may locate the wireless power receiver 200 on a region in which the LED lighting (SP110) is turned on.

In this case, the wireless power receiver 200 may be naturally aligned with the transmitting coil.

FIG. 31 is an exemplary view illustrating an auxiliary means for alignment aid or Align Assistance according to another embodiment disclosed herein.

Referring to FIG. 31, the auxiliary means for alignment aid or Align Assistance with the receiving coil may be a display module.

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In case of FIG. 31, the display module may be a display device (D110).

The display device (D110) may be provided in the wireless power transmitter 100 or provided in a charging pad providing a charging region (R220).

For example, when the LED lighting (SP210) which is an auxiliary means for alignment aid or Align Assistance is provided in the charging region (R210), the display device (D110) may display guide information such as "Please dispose receiver at the center of the charging region".

In this case, the user of the wireless power receiver 200 may arrange the receiving coil at the transmitting coil according to the displayed guide information.

FIG. 32 is an exemplary view illustrating an auxiliary means for alignment aid or Align Assistance according to still another embodiment disclosed herein.

Referring to FIG. 32, the transmitting (Tx) coil assembly of the wireless power transmitter may include an interface surface (I110).

The interface surface (I110) may face the receiving coil of the wireless power receiver.

In this case, the auxiliary means for alignment aid or Align Assistance may be a marker or lighting means provided on the interface surface for alignment aid with the receiving coil.

The marker may perform the role of displaying a logo or other visual markings.

Furthermore, the marker may be adhered on the interface surface (I110) in the form of a sticker.

In case of FIG. 32, a marker displaying the content such as "Align!" is adhered on the interface surface (I110).

Through this, the user of the wireless power receiver may locate the wireless power receiver in a region to which the marker is adhered to, thereby adjusting alignment between the receiving coil and the transmitting coil.

The foregoing method may be implemented in a recording medium readable by a computer or its similar devices by employing, for example, software, hardware or some combinations thereof.

For a hardware implementation, the embodiments described herein may be implemented by using at least any one of application specific integrated circuits (ASICs), digital signal processors (DSPs), digital signal processing devices (DSPDs), programmable logic devices (PLDs), field programmable gate arrays (FPGAs), processors, controllers, micro-controllers, microprocessors, other electronic units designed to perform the functions described herein. For example, the foregoing methods may be implemented by the control unit 180 or power transmission control unit 112 in the wireless power transmitter 100, or implemented by the controller 280 or power receiving control unit 292 in the electronic device 200.

For a software implementation, the embodiments such as procedures and functions disclosed herein may be implemented with separate software modules. Each of the software modules may perform one or more of the functions and operations described herein. Software codes may be implemented by using a software application written in a suitable programming language. The software codes may be stored in the memory 150 in the wireless power transmitter 100, and implemented by the control unit 180 or the power transmission control unit 112, and similarly, stored in the memory 260 in the electronic device 200, and implemented by the controller 280 or the power receiving control unit 292.

The scope of the invention will not be limited to the embodiments disclosed herein, and thus various modifications, variations, and improvements can be made in the

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present invention without departing from the spirit of the invention, and within the scope of the appended claims.

What is claimed is:

1. A wireless power transmitter configured to transfer wireless power to a wireless power receiver, the wireless power transmitter comprising:

a transmitting coil assembly including:

a single transmitting coil configured to generate a wireless power signal and to transmit the wireless power signal to a receiving coil of the wireless power receiver,

wherein the single transmitting coil has an outer diameter and an inner diameter such that the single transmitting coil is configured to form a hollow portion; and

a shielding portion configured to shield a transmission of the wireless power signal in a specific direction, and provided with a recessed structure for accommodating the single transmitting coil,

wherein the shielding portion extends at a first predetermined distance beyond the outer diameter of the single transmitting coil, and the shielding portion is placed a second predetermined distance below the hollow portion.

2. The wireless power transmitter of claim 1, wherein the specific direction is a direction opposite to a direction in which the wireless power signal is transmitted to the receiving coil.

3. The wireless power transmitter of claim 1, further comprising:

an auxiliary interface surface for aligning with the receiving coil of the wireless power receiver.

4. The wireless power transmitter of claim 3, wherein the auxiliary interface surface is at least one of:

a display module configured to illuminate a light emitting diode (LED) to indicate an alignment position,

an audio output module, or

a haptic module.

5. The wireless power transmitter of claim 3, wherein the auxiliary interface surface is a marker or a lighting device marked on the auxiliary interface surface for aligning with the receiving coil of the wireless power receiver.

6. The wireless power transmitter of claim 1, wherein the first predetermined distance is at least 2 mm.

7. The wireless power transmitter of claim 1, wherein the second predetermined distance is 1 mm.

8. A wireless power transmitter configured to transfer wireless power to a wireless power receiver, the wireless power transmitter comprising:

a transmitting coil assembly including:

a single transmitting coil configured to generate a wireless power signal and to transmit the wireless power signal to a receiving coil of the wireless power receiver,

wherein the single transmitting coil has an outer diameter and an inner diameter such that the single transmitting coil is configured to form a hollow portion; and

a shielding portion configured to shield a transmission of the wireless power signal in a specific direction, and provided with a recessed structure for accommodating the single transmitting coil;

an interface surface configured to transfer the wireless power signal from the wireless power transmitter to the wireless power receiver,

wherein the hollow portion is placed between the shielding portion and the interface surface,

wherein the hollow portion is placed a first predetermined distance below the interface surface, and

wherein the hollow portion is placed a second predetermined distance over the shielding portion.

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9. The wireless power transmitter of claim 8, wherein the specific direction is a direction opposite to a direction in which the wireless power signal is transmitted to the receiving coil.

10. The wireless power transmitter of claim 8, further comprising:

an auxiliary interface surface for aligning with the receiving coil of the wireless power receiver.

11. The wireless power transmitter of claim 10, wherein the auxiliary interface surface is at least one of:

a display module configured to illuminate a light emitting diode (LED) to indicate an alignment position,  
an audio output module, or  
a haptic module.

12. The wireless power transmitter of claim 10, wherein the auxiliary interface surface is a marker or a lighting device marked on the auxiliary interface surface for aligning with the receiving coil of the wireless power receiver.

13. The wireless power transmitter of claim 8, wherein the first predetermined distance is at least 1.75 mm.

14. The wireless power transmitter of claim 8, wherein the second predetermined distance is 1 mm.

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